THE MAGAZINE OF VISUAL PROCESSING

NUMBER THIRTEEN

INSIDE!


AN EXCERPT

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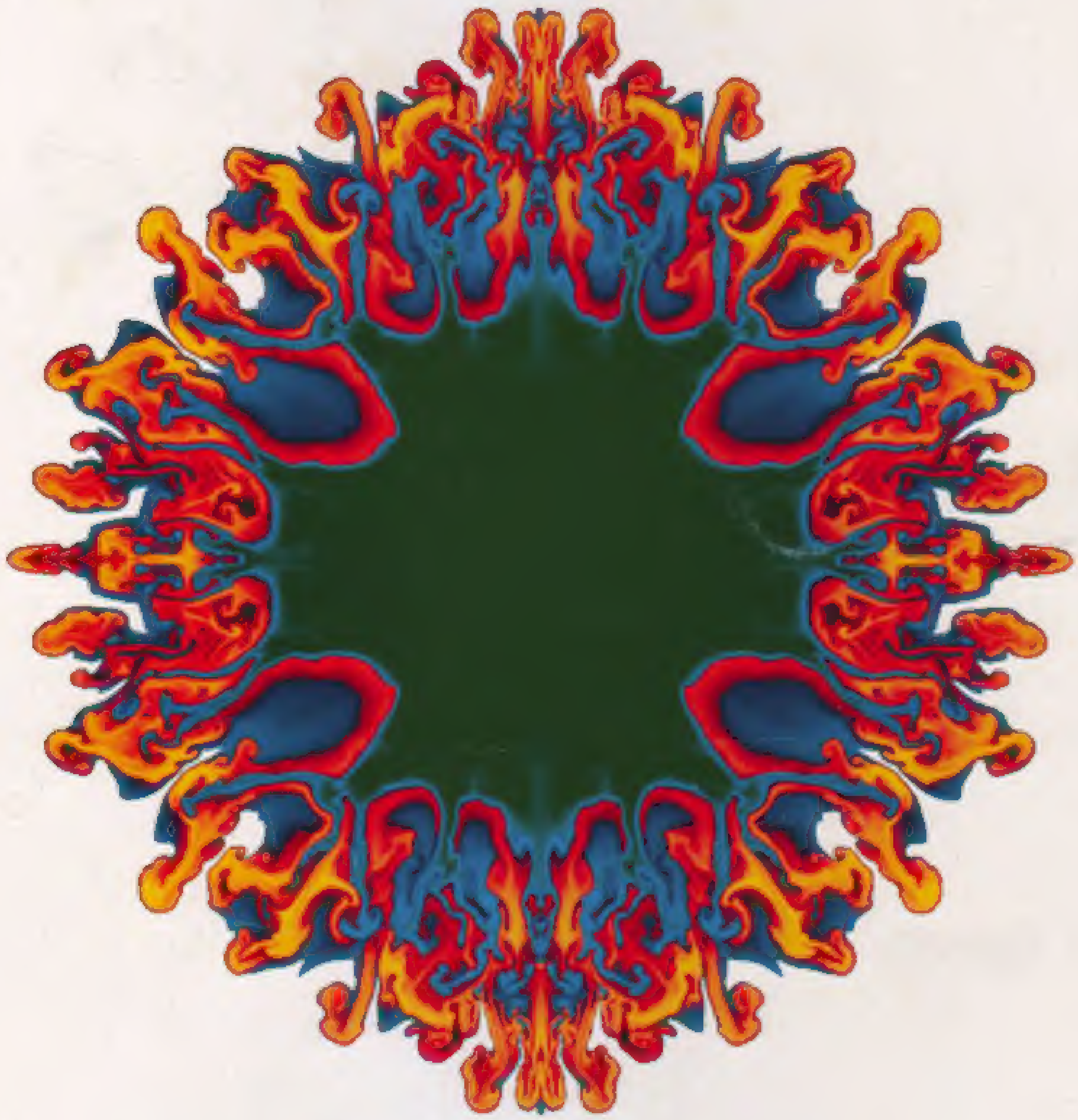

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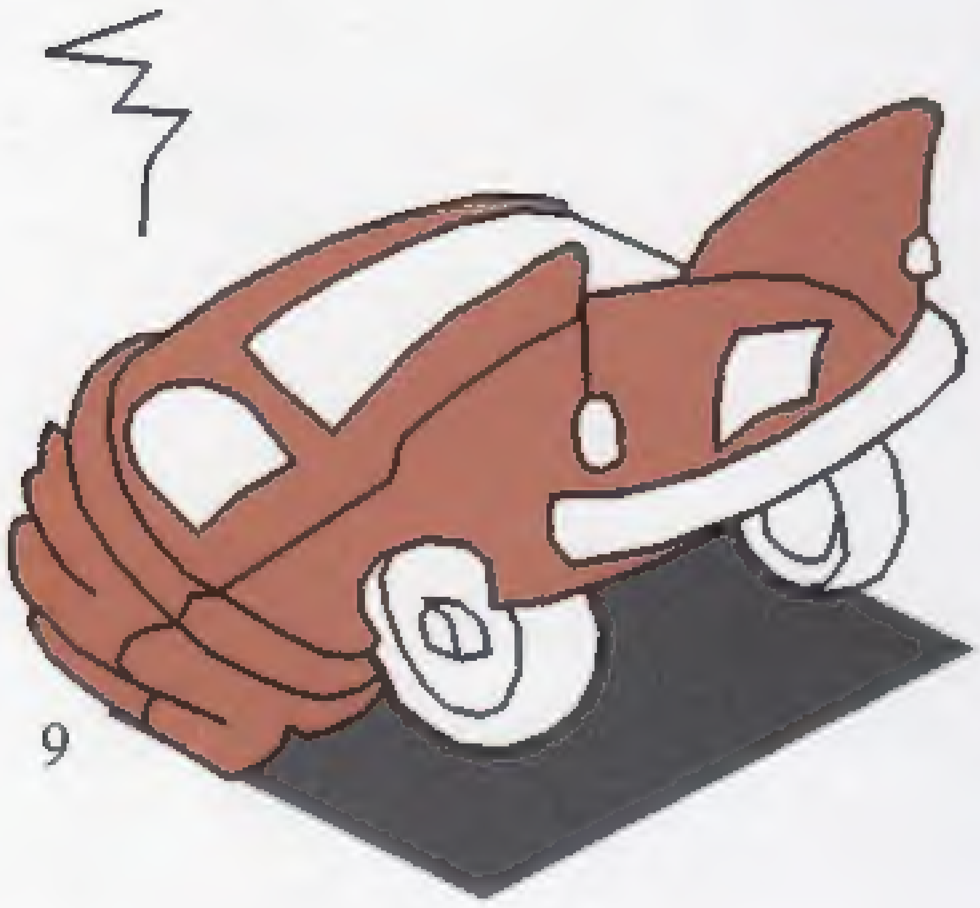

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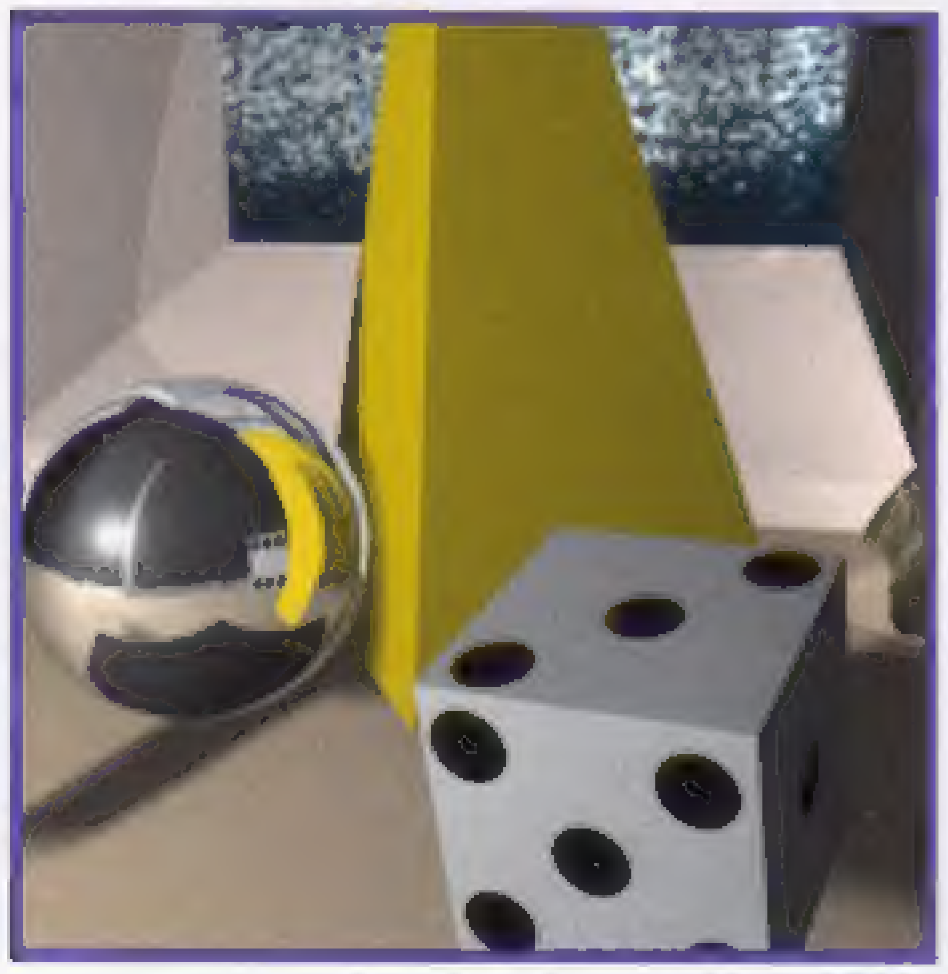

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**FEATURES**



**DEPARTMENTS**

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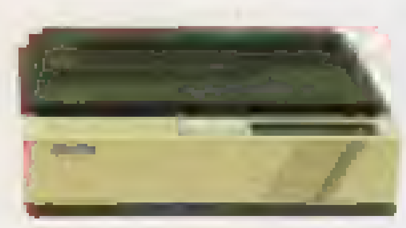

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**EDITOR**
Douglas Cruickshank

**CONTRIBUTING EDITORS**
Gaye Graves
Pramod Rustagi *(Solutions)*

**PAGE DESIGN**
Julia Wieczkowski

**DIGITAL IMAGES**
Monica Schulze and Paul Haeberli
Full-Color Publisher™

**TYPESETTING**
Lauren Langford Typography

**COLOR SEPARATIONS & PRINTING**
Lithographix

**EDITORIAL**
Silicon Graphics, Inc.
2011 N. Shoreline Blvd.
Mountain View, California 94039
415/335-1727

**CIRCULATION**
Monica Schulze
Silicon Graphics, Inc.
2011 N. Shoreline Blvd.
Mail Stop 415
Mountain View, California 94039
415/962-3320
*<monica@sgi.com>*

**ADVERTISING**
Ardith Lowell
MKT.
2755 Campus Drive #247
San Mateo, California 94403
415/341-9681

**PUBLISHER**
Mark Compton


## ON THE COVER

Supernova 1987A in the Large Cloud of Magellan as output on a Silicon Graphics 4D240 and 4D/20 at the University of Arizona, Tucson. For details about the creation and signifigance of these images, see "Journey to the Center of a Supernova" beginning on page 24.

Book cover inset: courtesy Harry N. Abrams, Inc.

## DON'T FORGET TO WRITE

*Magazine editors are almost like normal human beings; they too enjoy getting mail. And they feel much the same way about the letters they receive as they do about their children — good or bad, kind or cranky, they like them all. Every now and then, to give readers a break from the editorial holding-forth that normally appears in this space, we'll publish a selection of recently received letters. To do this we need your help. Whether you wish to bring something new to our attention, praise, admonish, or question us, please, don't forget to write.*

*—Editor*

Dear Editor,

I just received a copy of *IRIS Universe* (Issue No. 12) and was surprised and delighted to see the article by Kenneth Jolls and Daniel C. Coy (The Art of Thermodynamics) on thermodynamic surfaces. I am pleased to see connections being made between modern visualization technologies and important visual thinkers. I think this may prove to be an unexpectedly powerful combination.

The article was of special interest to me because I am currently completing preparation of a book on visual thinking. Also, I was particularly intrigued with your editorial note on the "convergence of science and art" — as this is one of the underlying themes that comes out of my research.

*— Thomas G. West*
*National Institute of Health*
*Bethesda, Maryland*

Dear Editor,

Too industrial. Too much emphasis on machines, we get that information elsewhere. Please focus on writing graphics tools in source code or using GL libraries more effectively.

The articles that dealt with how to do motion-blur ("Imitating Life," Joshua Mogal; Issue No. 11) and how to use the Z-Buffer ("The Hidden Charms of Z-Buffer," Kurt Akeley; Issue No. 11) are examples of what we'd like to see more of.

*—Jim Polk*
*Post Production Services, Inc.*
*Fairfield, Ohio*

Dear Editor,

"Solutions" ("Degenerating to Wireframe for Viewing," Pramod Rustagi, Issue No. 11) was very useful. I'd like to see more of this in future issues.

*—Chuck Gendrich*
*Michigan State University*
*Okemos, Michigan*


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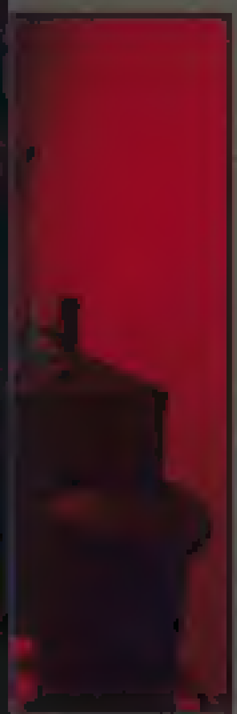
# SEQUENCE

*By David Haxton*




*As you can see, this issue's "Sequence" is somewhat of a departure from our usual approach — it's not strictly a sequence. You're looking at a selection of images, some in sequence, from a computer animation entitled "Camerawork." In the following text, instructor David Haxton describes the project.*

— *Editor*

Each year The Center for Computer Art and Animation at William Paterson College, in Wayne, New Jersey, produces a computer animated film. I serve as the director and creator of the projects. Undergraduate and graduate students work with me in the execution of these animations. This year the primary production group consisted of Thomas Lee, first assistant director, Craig Kovacs, second assistant director, Wayne Herman, technical director, and Tod Worden, Production Manager. Many other students took part in the creative and production processes.



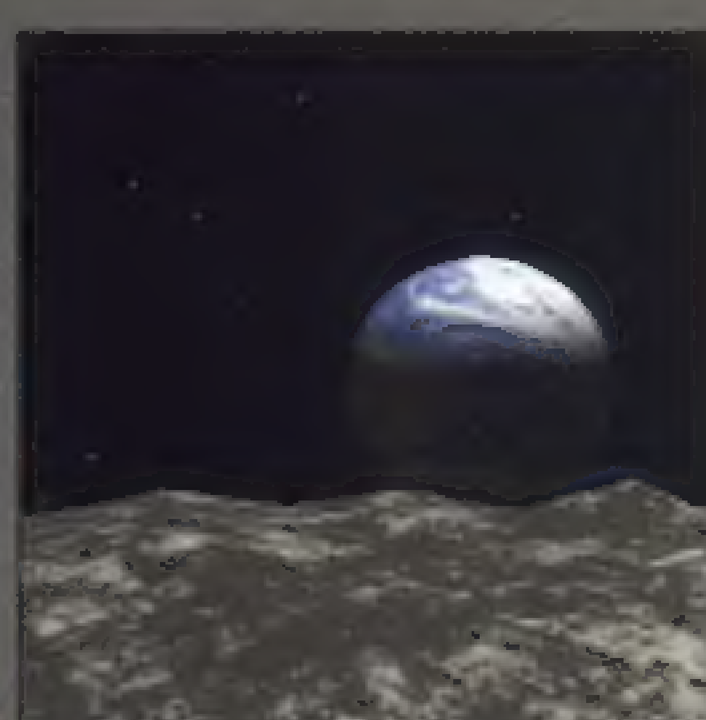
The animations are produced by undergraduate and graduate students in the school's computer graphics program. The current project, "Camerawork," which will be entered in SIGGRAPH '90, is about cameras and photographs. 3D cameras are animated in a computer generated photo studio. One of the cameras focuses on the darkroom, lit by a red bulb. The viewer enters the room to observe four famous photographs recreated as three-dimensional models which then come alive.

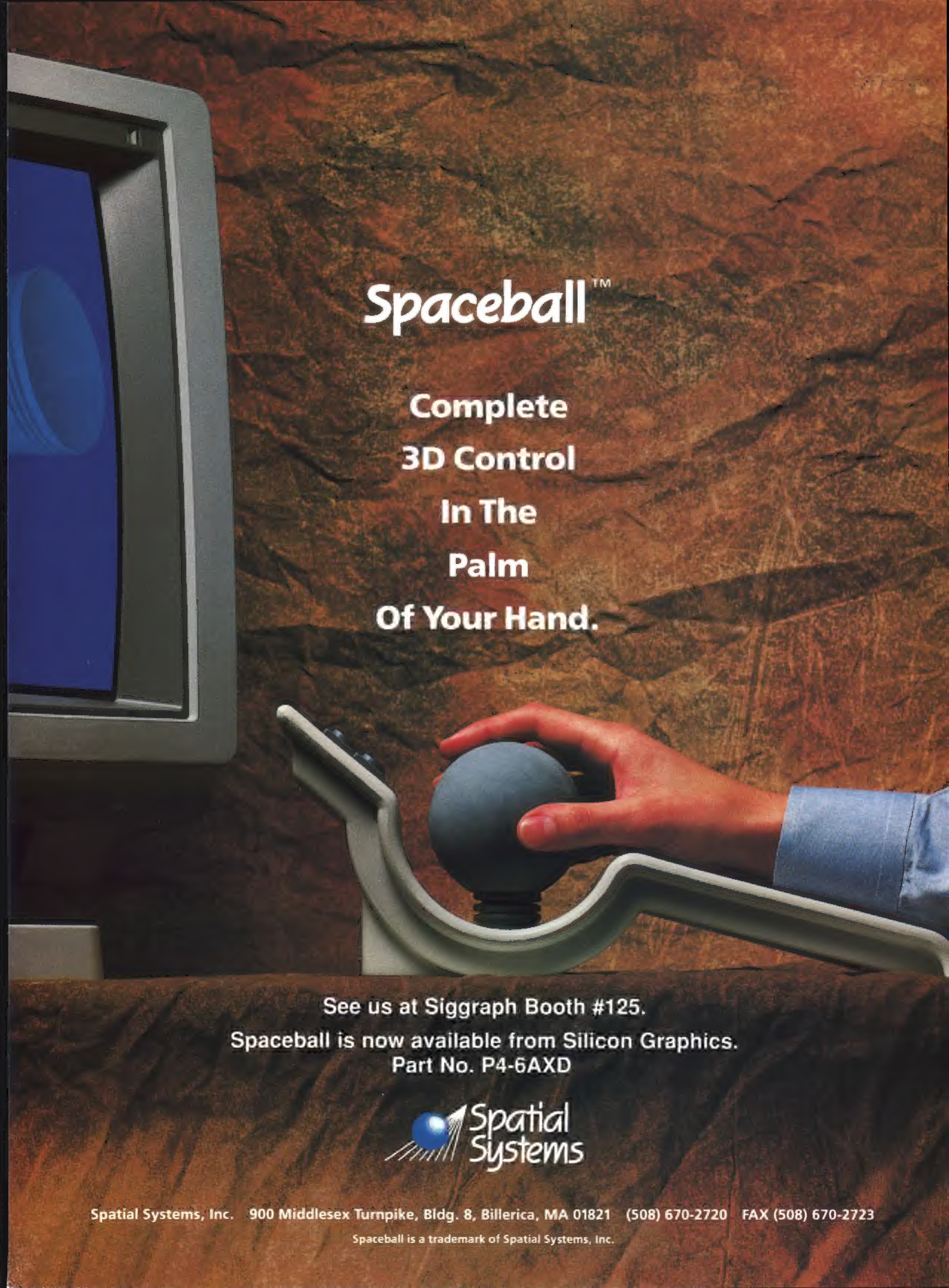
"Camerawork" was produced using five Silicon Graphics IRIS 3130 computers, two 4D/80GTs, one 40/25, and a CS-12. Alias software was used to create the models and animation.

Computer animated films previously created at the Center include "The Art Dream" and "Columbus on The Edge."

*David Haxton is on the faculty of William Paterson College.*



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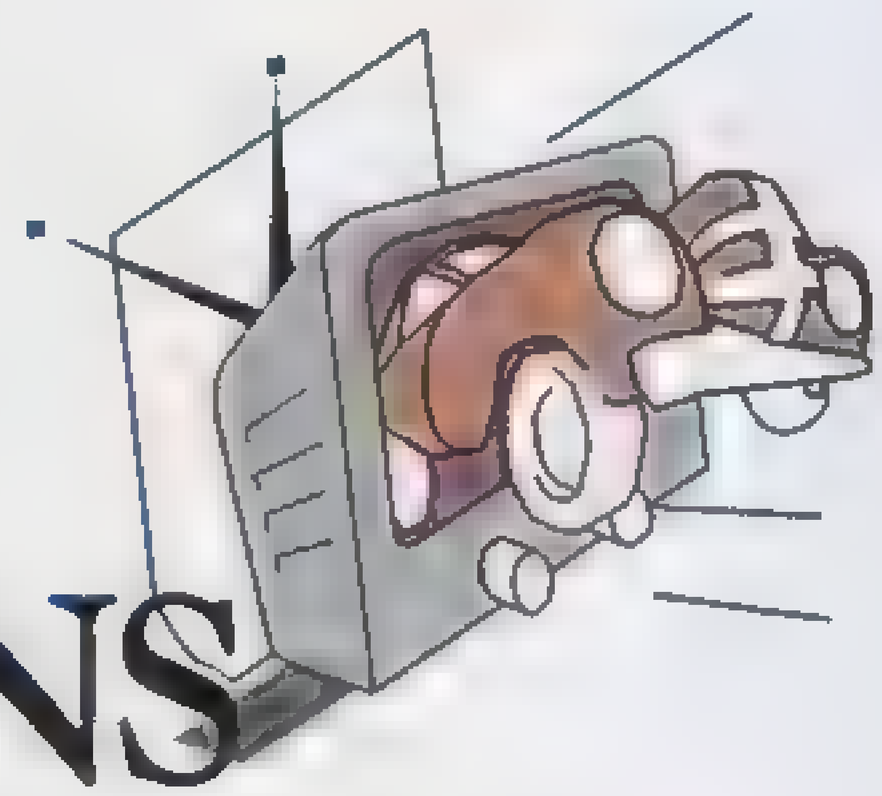
# THOSE GORGEOUS ICONS

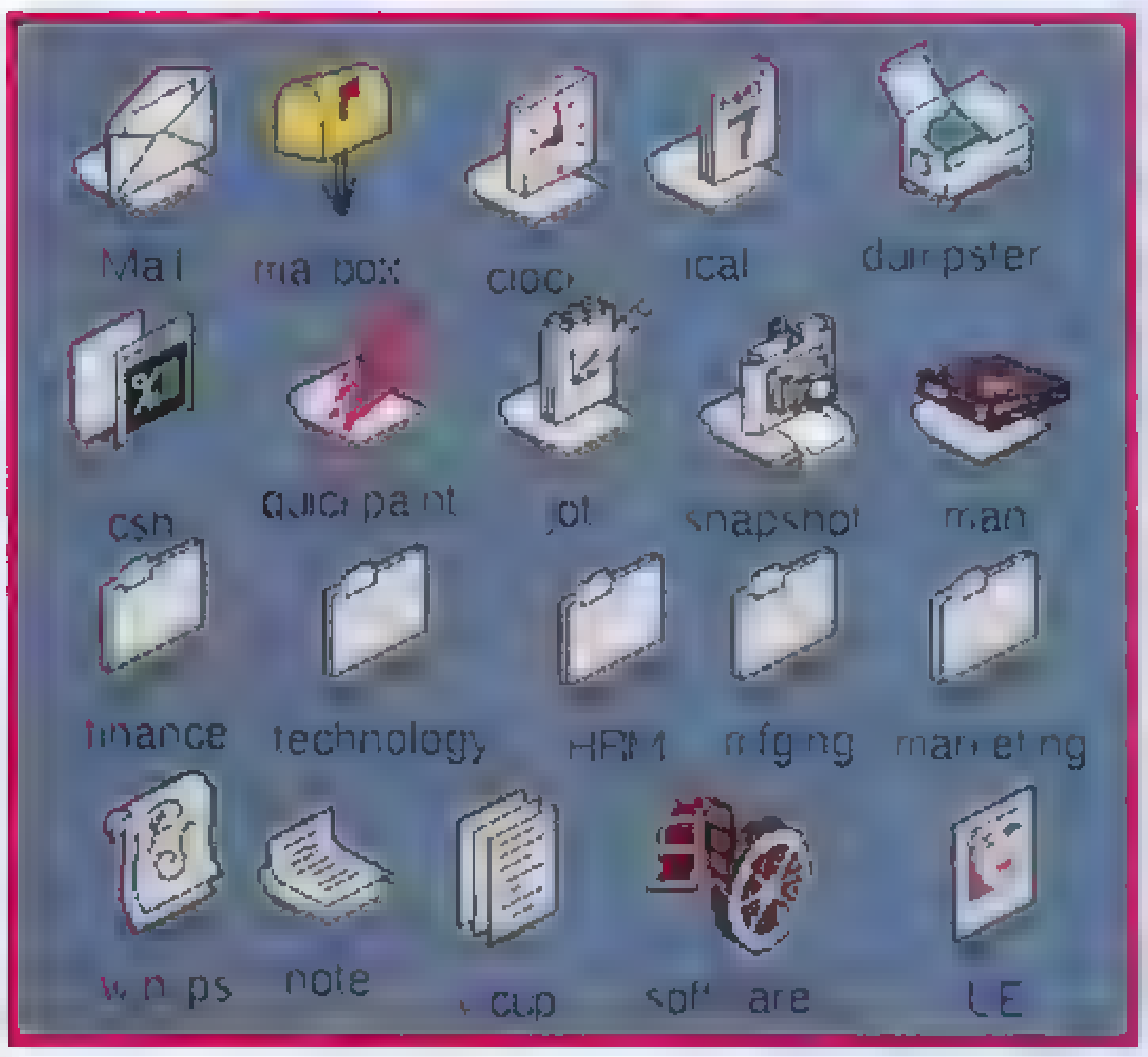


*With the new Iconsmith you can make the WorkSpace an even friendlier place to work.*

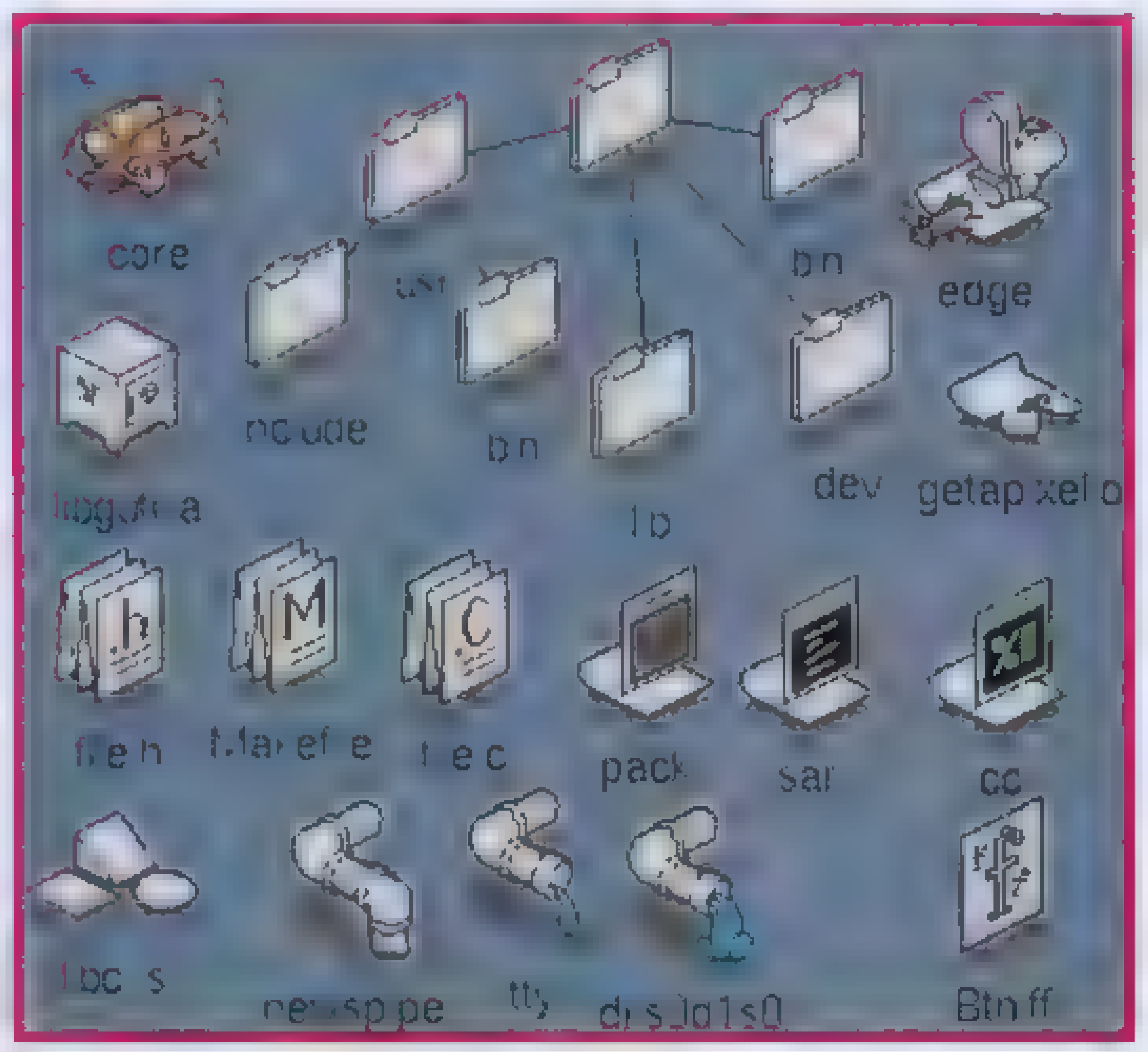
BY JOHN EDELSON

Today, when you turn on an IRIS workstation, you enter an interactive, color environment where you are greeted by a crowd of friendly icons. Gone are the days when users found themselves face-to-face with a blinking prompt. Today, the WorkSpace is populated with helpful characters that give you the power of a Unix-based system and allow you to perform your work without learning the arcane commands that used to be required.

The WorkSpace provides users with a visualization of the previously mysterious file system. By being able to see the files, users are given the same visual memory clues to where things are stored as they are given in the real (not computer) world. WorkSpace can be customized so that individual users (even those using the same machine) can choose what should be kept visible and what should be hidden. For example, one user, we'll call Ed, might decide to "see" only those files and applications that he uses and to see them as a number of choices without any hierarchial structure. On the other hand, a second user, named Jim, might want to see the




*Ed's view of his WorkSpace.*




*Jim's view of his WorkSpace.*

file structure. The WorkSpace allows both Ed and Jim to have their own view of the system. This is true if the users are sharing the same machine or if they are all NFS mounting files from a centralized server (yes, mounted files do appear in WorkSpace exactly like local files).

WorkSpace is built around a few basic icons. These icons can be combined with "emblems". For example, the QuickPaint™ emblem sits on top of the executable symbol or the data symbol to represent the QuickPaint executable or a QuickPaint data file. The executable icon moves from a horizontal position to a vertical one when the program is running.

The WorkSpace goes beyond a simple visual display of Unix commands. WorkSpace provides each icon with quick, intuitive behavior. For example, opening (double clicking) an ASCII text file opens the text editor application and loads the document. And while the default text editor for the WorkSpace is Jot, users are free to subsitute the editor of their choice, such as Emacs or VI.

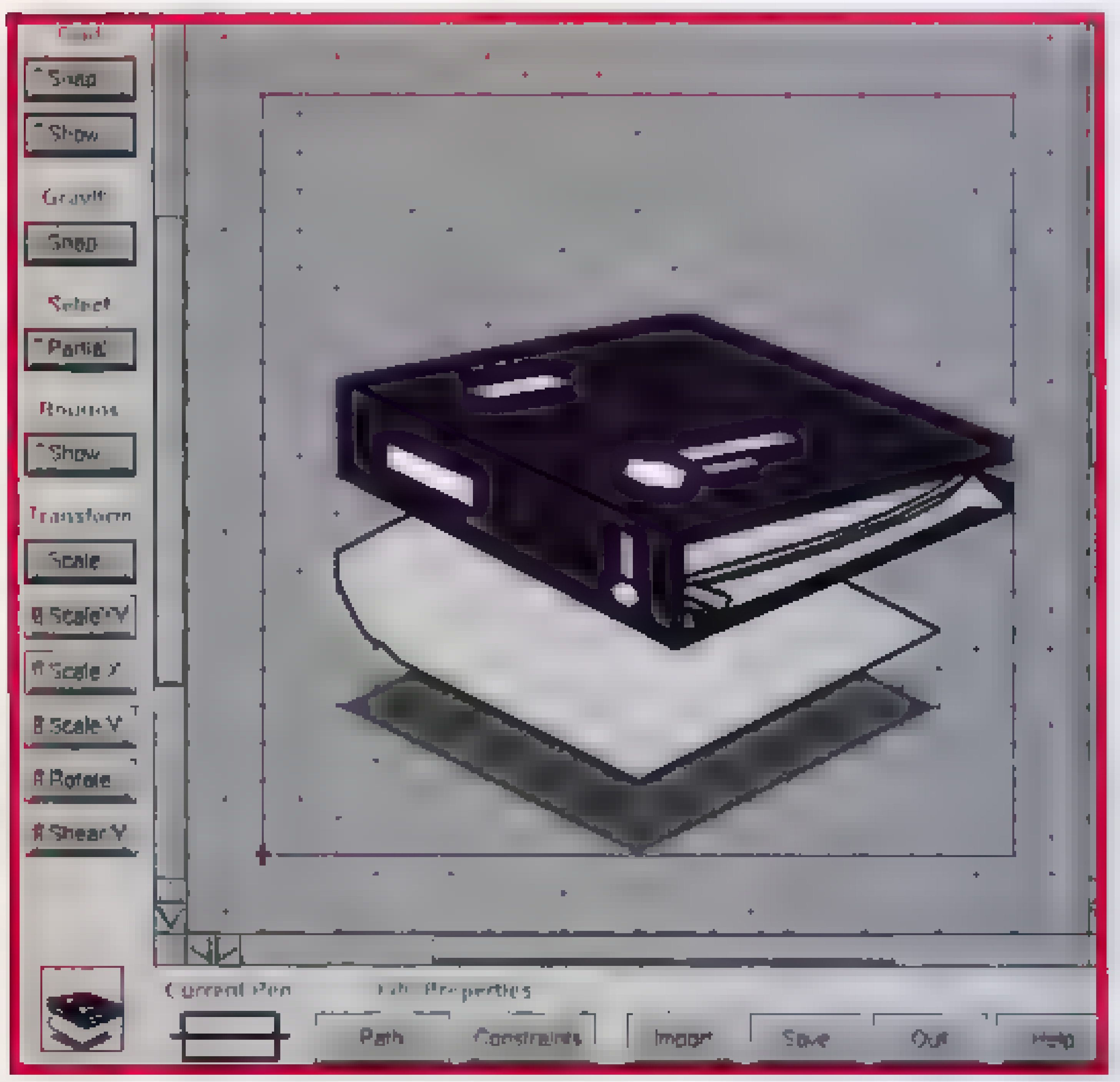
Each application developer can integrate his program into WorkSpace by providing his own unique icon possessing customized behavior. If a programmer chooses not to create his own icon, the WorkSpace automatically assigns generic program and data icons complete with rules for their behavior. The method for determining the interactions and behavior of the icons is established in the file typing rules. The process for assigning these behaviors is documented in *Programming the IRIS WorkSpace* (distributed with the *Development Environment Manual Set*). For more hints on how to use these rules, look in the Fall and Winter editions of SGI's Customer Support *Pipeline*.



**(Above)** ***The demo icons.*** **(Right)** ***The sky's the limit when designing icons with the Iconsmith.***

Some programs rely on the WorkSpace not only as a method for loading the program, but as a way to organize and select data, or as a significant portion of the user interface. Icons give a clear identity to a program and provide an integrated feel to the product. The new Iconsmith software is an interactive program designed to help you in creating your own icons. Iconsmith also contains tools and hints for getting that three-dimensional look. Iconsmith is available upon request, free of charge, from Silicon Graphics' User Services (contact Monica Schulze at Silicon Graphics <monica@sgi.com>, 415/ 335-1532).

In future articles, we will show how different developers have integrated their programs into the WorkSpace. If you are proud of your icon or of your method for integrating into the WorkSpace, I'd like to know about it. John Edelson 415 335-1532 <edelson@sgi.com.>



***The Iconsmith is a specialized draw program used for creating icons for the WorkSpace.***

*John Edelson is an Applications Software Manager at Silicon Graphics.*

# A WINDOW ON THE UNIVERSE

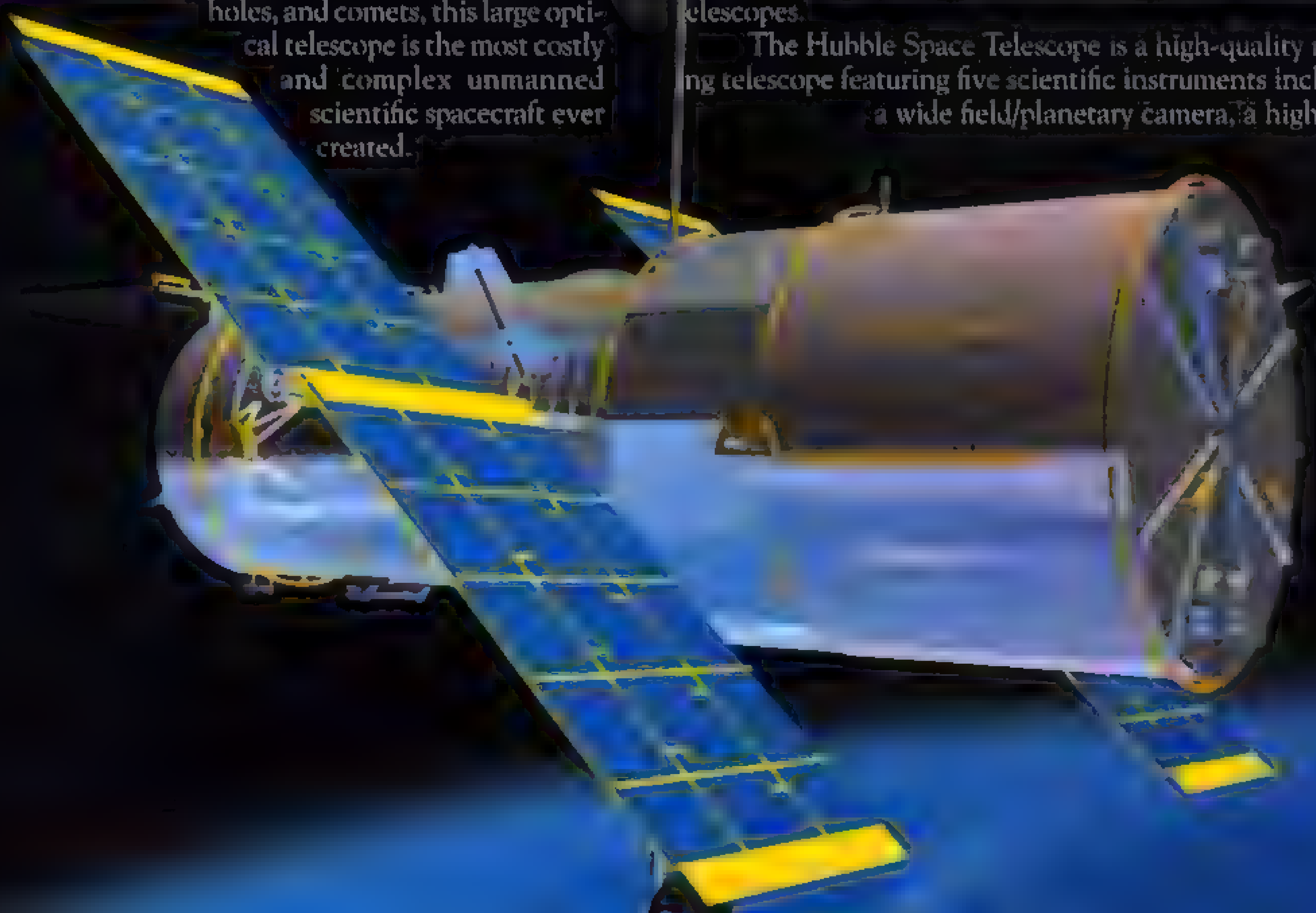
*Scientists may soon be able to see deeper into space and farther back in time than ever before. Computer visualizations will be used to give them a fuller understanding of their discoveries.*

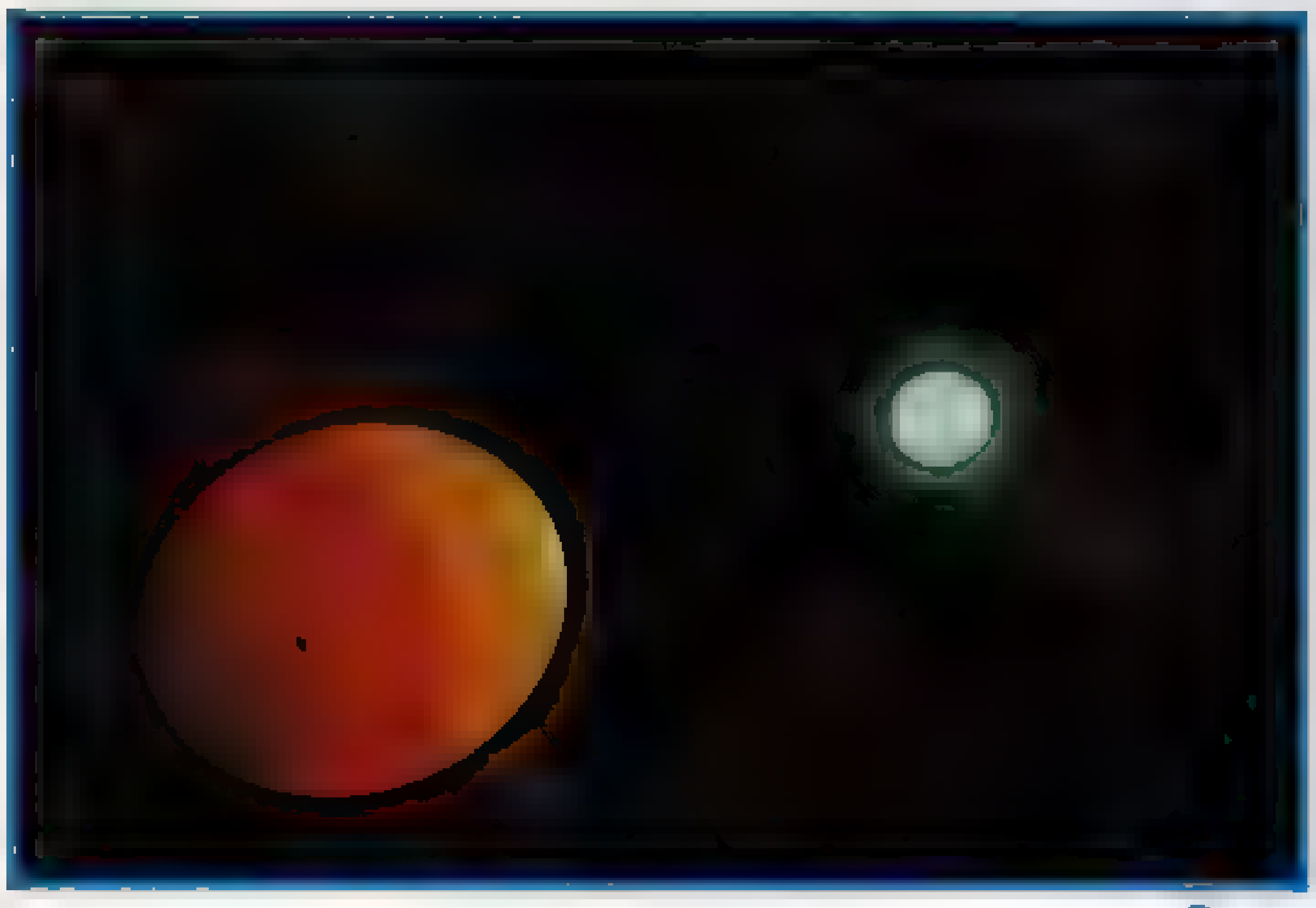
BY JILL GROSSMAN

The successful liftoff of the Space Shuttle *Discovery* from Kennedy Space Center, Florida at 8:34 a.m., April 24, 1990 marked the launching of the Hubble Space Telescope (HST) into low earth orbit. Searching for undiscovered galaxies, black holes, and comets, this large optical telescope is the most costly and complex unmanned scientific spacecraft ever created.

The Hubble Space Telescope promises a dramatic increase of knowledge in the field of astronomy. According to industry experts, Hubble will provide scientists with ten to one-hundred times more detail on the universe than the best Earth-based telescope. Unhampered by Earth's atmospheric distortion, resolution of the obtained images is expected to be seven to ten times greater than images from Earth-based telescopes.

The Hubble Space Telescope is a high-quality reflecting telescope featuring five scientific instruments including: a wide field/planetary camera, a high-speed





(Left to right) ***Stills from a computer animation of the comet Kohoutek.*** (Right hand page) ***A black hole. All images by Dana Berry.***

photometer, a faint-object camera, a faint-object spectrograph, a high-resolution spectrograph and fine-guidance sensors. These instruments will enable scientists to study ultraviolet and visible light rays. The instruments will be able to provide information on the visual appearance, size, brightness, chemical composition, age and distance from the Earth of celestial objects.

## Scientific Visualization

Because cosmic events take place over millions of years, even with the Space Telescope, it is impossible to collect enough pictures to create a true sequence of events. Instead, computer graphic artists like the Space Telescope Science Institute's Dana Berry, help astronomers visualize their research. They take the information from Space Telescope photos and create computer models. Additionally, data is imported to drive the animation that has been created.

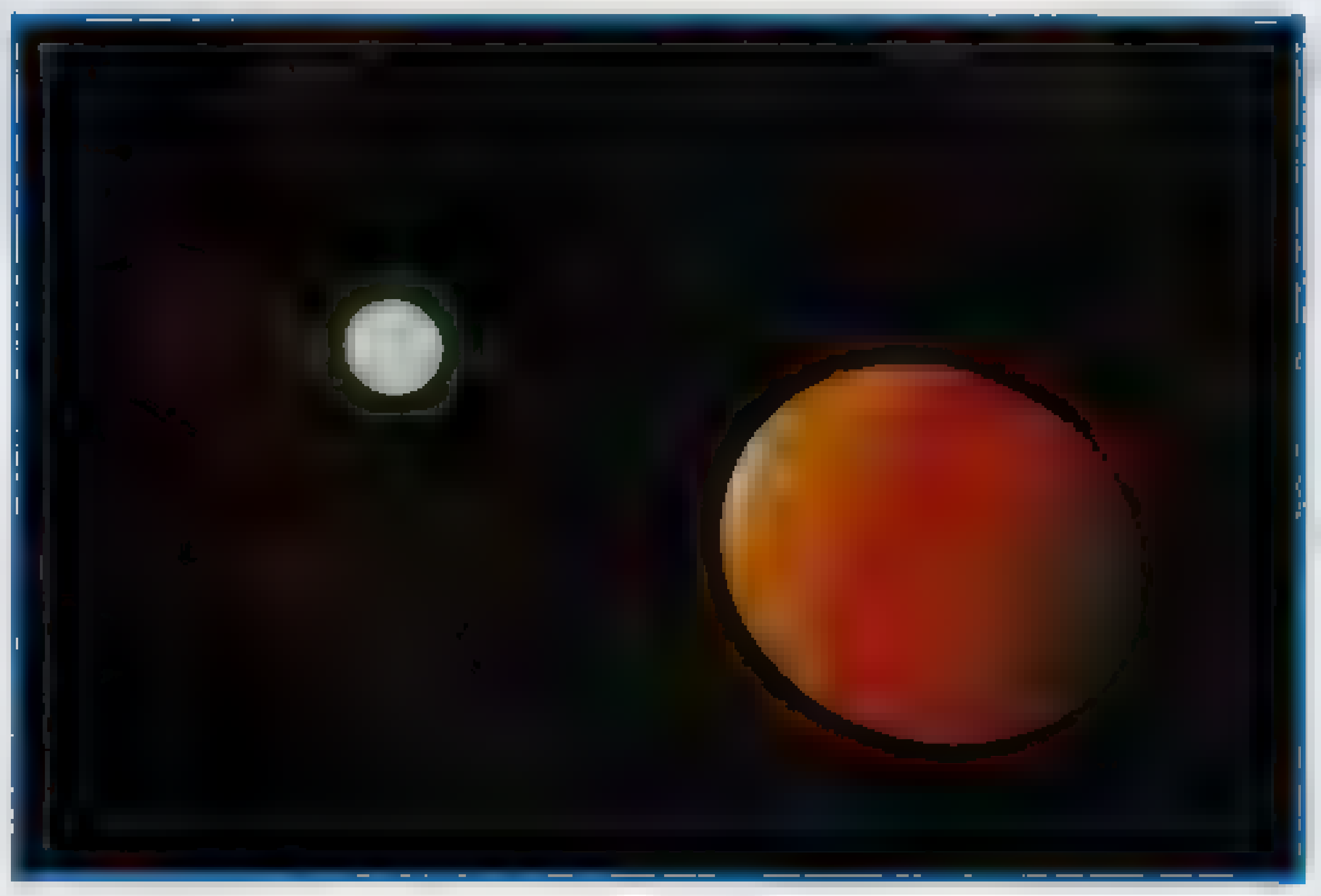
An example of Berry's success involves the study of a galaxy with a very active core called Virgo A. Single frame photographs have indicated that there are jets running along the polar axis of the galaxy. It is those jets, when visualized in a sequence, that have lead the astronomers to believe that Virgo A contains a super massive black hole — a hypothetical celestial body with an intense gravitational field that is held to be a collapsed star.

Astronomers at the institute use visualizations like the one described to simulate abstract discoveries, and convey them to their colleagues, their peers and the general public. Silicon Graphics workstations and servers combined with Alias software provide the vehicle for these visualizations.

## Information Management

Researchers at the Science Institute are responsible for managing the scientific operations of the telescope, analyzing the returned data and acting as the interface for the scientific community. Their responsibilities range from acquiring and calibrating data to physically distributing the data to other scientists.

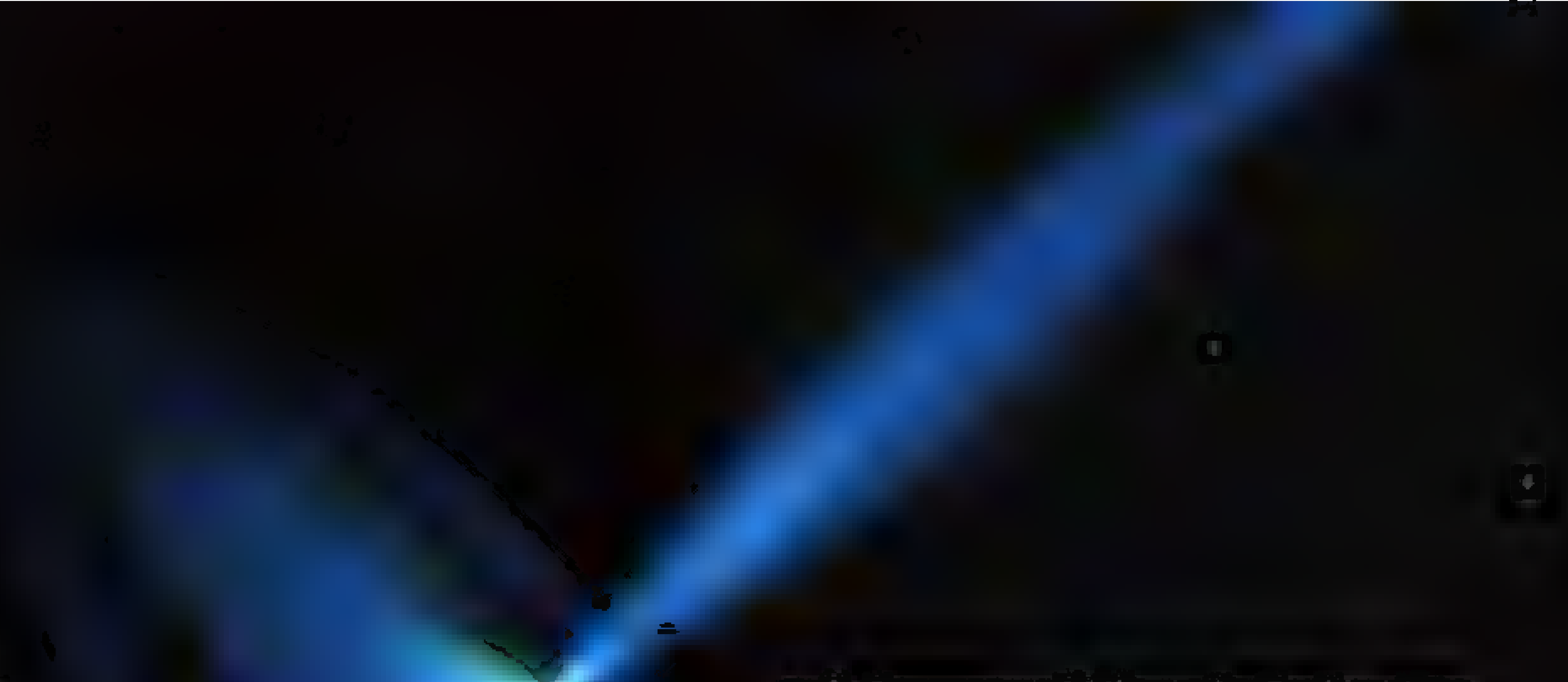
Peter Shames, Chief, Information Systems Development Branch, heads the group that is responsible for advanced systems development for the Space Telescope.



Shames' charter has involved the integration of workstations, wide area networks, and local area networks at the Science Institute. Currently, he is engaged in a range of projects that includes the building of a large scale optical disk archive. The present archive supports almost one terabyte of data on current technology optical disks. The archive runs in a client/server environment; the server database and archive provides access for the UNIX and VMS workstation systems on site.

An external project called the Astrophysics Data System (ADS) involves similar activities on a much larger scale. The project calls for the creation of a distributed information service that provides access to the astronomical activity at facilities around the U.S. and provides access to the information to NASA scientists throughout the country. Databases like the Guide Star Catalog, which provides information about 20 million stellar objects, is planned to be made available online. Catalogs from other sites are also being placed online.

As the Space Telescope is operated, an on-line catalog



will be generated that will make new information accessible. Researchers will then be able to gain access to the information and learn of the observations other scientists using the system have made. Use of the archive data following the end of a proprietary period is a key aspect of the Hubble Space Telescope project. The ability to combine observations from the Hubble with infrared, ultra violet, radio and x-ray data from other telescopes will permit ADS users to make fundamental new discoveries.

The distributed system will be designed to handle requests from a heterogeneous mix of computer systems.

However, in order to provide a central server, an extensive amount of affordable compute power is needed. Because of its parallel processing capabilities, which will enable researchers to drastically reduce search time, the Silicon Graphics 4D/220S was chosen to handle the task. Serving as a central node in the ADS, it will play a key role in providing a centrally accessible text retrieval engine to a master director of all of the ADS sites, facilities, and services.

Because it is a new system, wide scale user access will not be available until later in the year. Initial sites participating in the project include: the Smith Astrophysical Observatory at Harvard, the Space Telescope Science Institute at Baltimore, Infrared Processing and Analysis Center at Caltech, International Ultraviolet Explorer Data Centers at NASA Goddard and the University of Colorado. As the system gains momentum, other sites and other scientific databases are likely to be added.

## Out in Space and Back in Time

As the largest orbiting observatory ever built, the Hubble Space Telescope, is expected to bring a revolution in astronomy. According to the Big Bang theory of creation, the universe may be fifteen billion years old. The Hubble Space Telescope, capable of imaging objects up to fourteen billion light years away, will be able to capture and magnify light from the edge of the universe — and allow man to see out in space and back in time. Built to the limits of what technology can provide, it should help scientists solve the mystery of black holes, quasars and phenomena not yet imagined.

As Charles Pellerin, director of NASA's Astrophysics Division, describes, "it is a voyage much like the voyages of Columbus and Magellan, except that it's a voyage of man's intellect in the universe."

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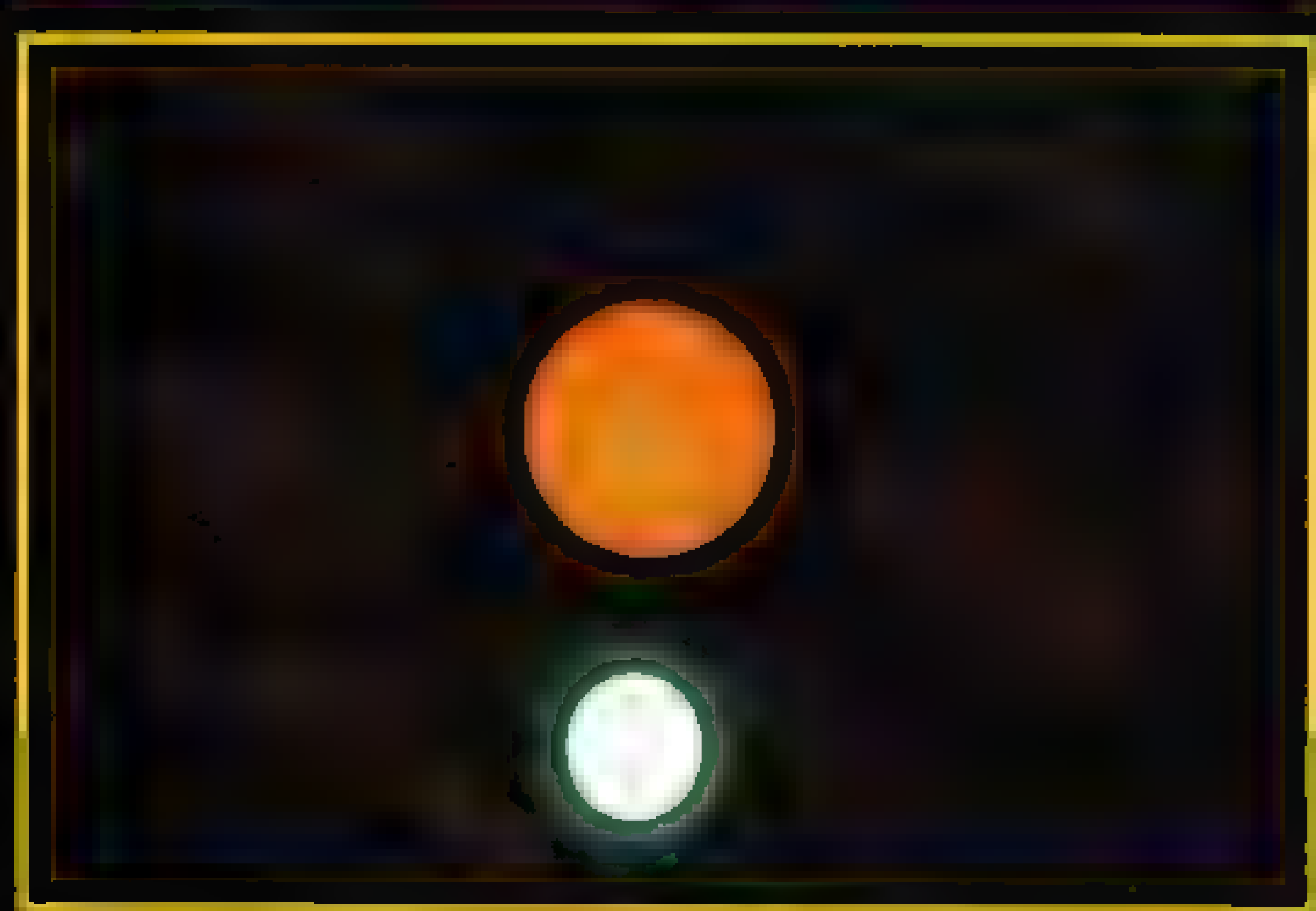
*Jill Grossman is a Public Relations Specialist at Silicon Graphics.*



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# VISUAL THINKING WITH COMPUTERS

*The most striking — and a unique — feature of mind is the acceptance and use of things as symbols standing for other things. Symbols may stand for, refer to, or mean other things which may or may not lie within the world of physics...In this sense we find Mind in computing machines.*

— Richard L. Gregory
in **Mind in Science**

*Richard Friedhoff and I first met over the telephone. He called with a specific question but our conversation extended to a variety of issues having to do with visualization and computers. Shortly thereafter I came across a copy of Mr. Friedhoff's recently published book,* Visualization: The Second Computer Revolution *(Harry N. Abrams; 1989). The book is a handsome, heavily-illustrated volume with a comprehensive overview of computer visualization. Reviewing Friedhoff's book in a recent issue of* Scientific American, *Philip Morrision called it "engagingly accessible," and went on to say that "Computer savvy readers will ... enjoy the breadth of scene and profit from the pervasive sense of intellectual unity. For the less initiated reader, these nontechnical pages open on and simplify an epistemological revolution, one that already holds major territory within contemporary thought." We take pleasure in presenting the following brief excerpt from* Visualization: The Second Computer Revolution *and encourage you to seek out the volume in its entirety.*

*— Editor*

## BY RICHARD MARK FRIEDHOFF

The first images were found rather than made. People looking into the night sky, saw human figures, animals, and magic symbols in the stars. They did not realize that they were creating these images from scattered points of light, but felt that they were discovering what was already there. So real and so awesome were these celestial apparitions that they were sometimes taken to be gods.

Art historian E. H. Gombrich has suggested that the earliest painters did not consciously create. Prehistoric man, accustomed to searching for signs of his prey, discovered likenesses of buffalo and other animals in the irregular features of the walls of caves. At Lascaux and elsewhere pictures were rendered only to make vivid what was perceived to already exist in the stone. These too were found images.

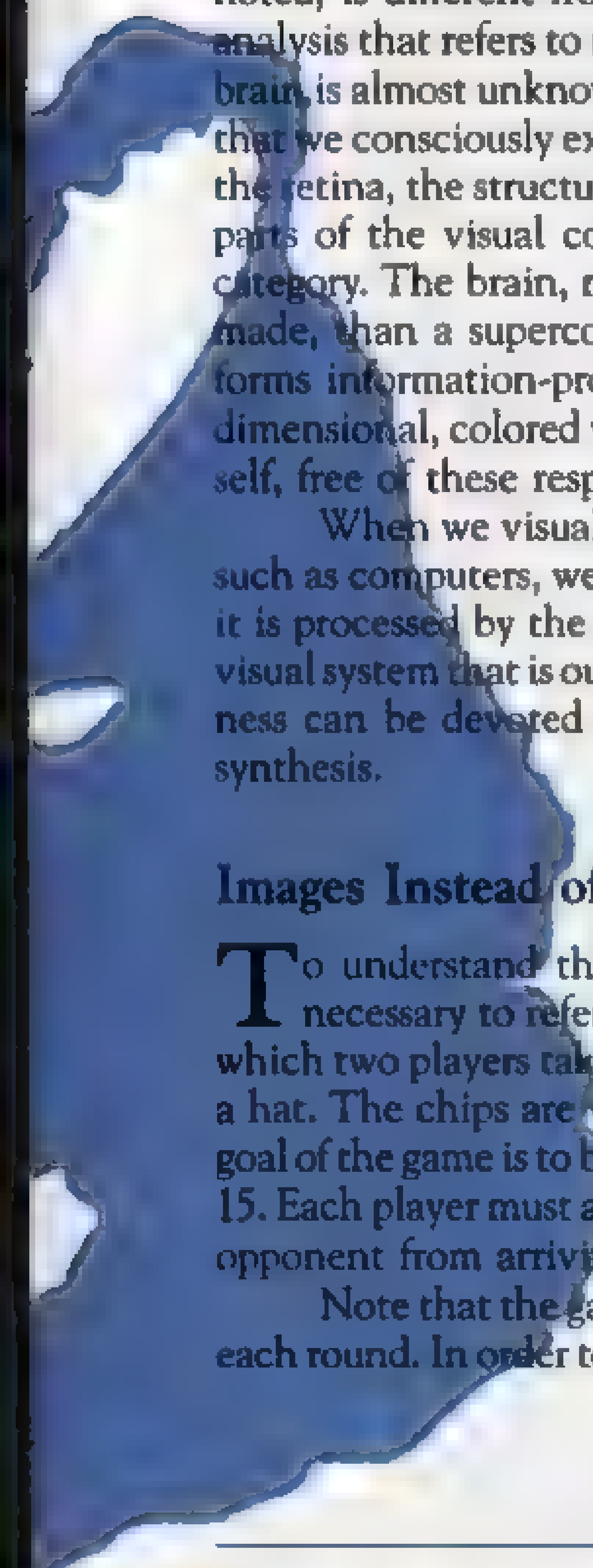
The tendency to impose form, whether on the surface irregularities of a cave, or in inkblots, clouds, or shadows, is suggestive of an organizing function of vision - an organizing tendency so strong that random shapes can trigger the perception of vivid illusions. It is in this organizing function that we begin to see the power of visualization.

Jacob Bronowski, the twentieth-century scientist and philosopher, has suggested that the auditory sense connects us with other living things but that it is vision which we use to understand the physical world. The importance of the visual system is further affirmed by the fact that a surprisingly large proportion of the brain is devoted to vision and visual analysis and the fact that the information-carrying capacity (the "bandwidth") of the visual system is greater than for any

other sense. These facts alone, however, do not fully convey my central theme: that the visual system — the eye and those parts of the brain that are dedicated to organizing visual information — can be made to take the place of conscious thought.

In order to understand how this occurs we first have to accept the distinction made by perceptual psychologists between conscious and preconscious processes. The term preconscious refers to lower-order information processing that is outside of voluntary control. This is distinct from the conscious or problem-solving self. (Preconscious, it should be noted, is different from unconscious, a term from psychoanalysis that refers to repressed thoughts.) Our preconscious brain is almost unknown to us, although it creates the world that we consciously experience. The visual system including the retina, the structures ascending to the visual cortex, and parts of the visual cortex itself fall into the preconscious category. The brain, more powerful, if a comparison can be made, than a supercomputer, relentlessly and silently performs information-processing miracles, creating the three-dimensional, colored visual environment that our conscious self, free of these responsibilities, enjoys so effortlessly.

When we visualize through the use of external means such as computers, we restructure a problem so that more of it is processed by the preconscious part of our brain — the visual system that is our silent partner. In this way, consciousness can be devoted to the highest levels of analysis and synthesis.



## Images Instead of Calculations

To understand the role of visualization it is not even necessary to refer to the computer. Consider a game in which two players take turns choosing numbered chips from a hat. The chips are visibly numbered 1 through 9 and the goal of the game is to be the first to draw three chips that total 15. Each player must also keep in mind the need to block the opponent from arriving at the sum of 15 first.

Note that the game requires a series of *computations* for each round. In order to evaluate alternative choices, a player must determine not only which chip will bring the total to 15 but must also consider the value the remaining chips would have for the opponent. A series of arithmetic calculations must be performed to make each move.

The game can also be played another way — visually. The arrangement of numbers 1 through 9 shown here has the special property that each row, column, and diagonal sums to

(Left) *A simple inkblot reveals the visual system's organizing power. Although its shape is arbitrary, it triggers the perception of recognizable forms. Prehistoric people similarly found forms, which were the basis for the first paintings, in the surface irregularities of the walls of their cave dwellings.* (Above) *Margaret Livingstone has suggested that the color channel of visual perception has lower visual acuity than the form channel. This helps to explain why the diffuse patches of color in Pablo Picasso's* Mother and Child *naturally relate to the sharply delineated forms.*

15 - the critical value required for victory.

| | | |
|---|---|---|
| 6 | 7 | 2 |
| 1 | 5 | 9 |
| 8 | 3 | 4 |

Since the rows, columns, and diagonals represent every possible combination that sums to 15, the square can be used to eliminate the computations needed to make each move. To win the game, a player simply picks three numbers within a single row, column, or diagonal. Instead of calculating arithmetically, the players choose boxes in the grid visually.

A convenient way of recording the player's choices is for one player to mark the boxes with x's and the other with o's. Played this way it immediately becomes apparent that the game can be simplified even further if numbers are forgotten altogether and choices are made by marking a clean grid. In this form, of course, the game is recognizable as tic-tac-toe. In the grid form, the game is more "intuitive" since it simply requires the completion of horizontal, vertical, or diagonal lines. The important point is that, in the second form, arithmetic calculation is exchanged for visual comparisons.

This example captures the essence of visualization: a successful visualization removes computational barriers so that we may proceed with strictly visual comparisons. In this particular example, arithmetic is exchanged for the visual system's ability to measure co-linearity, the property of objects being arranged in a line. The ability to judge colinearity is a basic visual competency about which much is known at the physiological level. For example, we know that colinearity is judged by a visual sub-sense quite distinct from the subsenses responsible for color, motion, or stereoscopic depth.

In this example, a conscious process has been replaced by a preconscious process. In tic-tac-toe, the computations required are simple and the game can be played satisfactorily in either form. In science, engineering, and design, however, computational barriers to alternative testing can be much more formidable. In these cases, visualization can change the whole nature of the game.

The connection between the preconscious processes of visual perception and visualization is becoming more obvious every day. For example, Margaret Livingstone of Harvard University Medical School has pointed out that by understanding the differences between the separate channels for color and form in the visual system, we can better select color schemes for visualizing complex scientific problems so as to maximally exploit the capabilities of the visual system. Until recently, we did not know that a poorly chosen color scheme would cause messages from the color channel to conflict with messages from the form channel thus obscuring important forms and producing visual artifacts. Despite visualization, conscious attention is required to decipher target forms. Conversely, a better color scheme results in congruent messages via the color and form channels so that forms are readily identified without conscious effort.

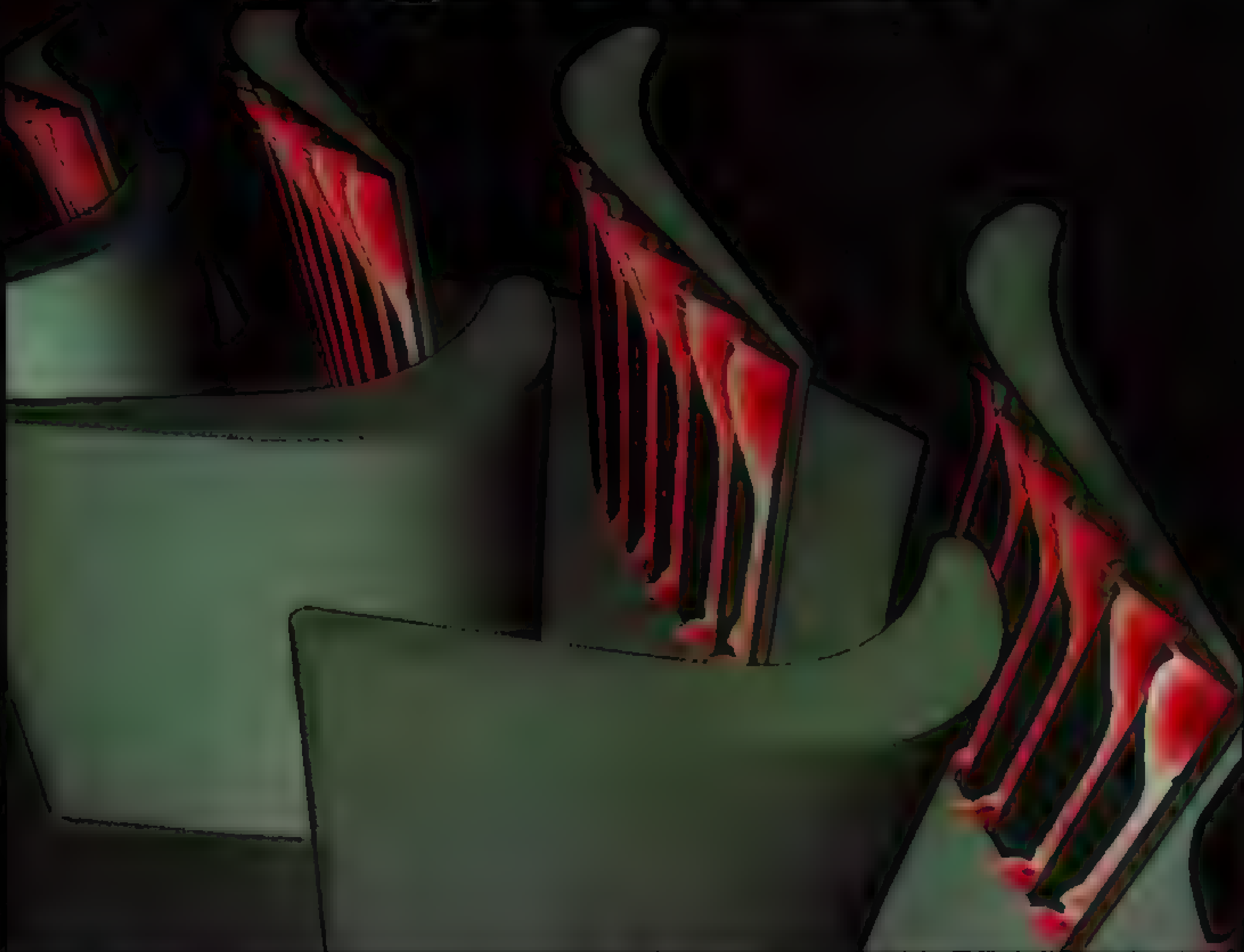
Understanding the differences between the color and form channels is also useful for understanding artistic images. Notice how the diffuse colors of Picasso's *Mother and Child* seem to gravitate to the sharply delineated forms. This is because the color channel of the visual system has lower visual acuity than the form channel.

Image processing with computers can be used to make all of the qualities of an image congruent with the way in which the human visual system processes visual information. The computer can be used to enhance, by various means, the informational value of an image pattern. The image-processing computer does not comprehend the content of the image but can do much to prepare it for human perception. The computer can be used, for instance, to remove blurring from images, to improve focus *post hoc*, and to identify important features, by comparing ensembles of images.

The key to developing the full potential of visualization will be to exploit our expanding understanding of the preconscious processes of visual perception. The eye and brain, functioning together, do not passively record but actively create the visual world. Visualization makes use of this tremendous information processing capability. This is both the mystery and the power of our new enterprise since it is difficult to conceive of a means other than visualization by which we could so exquisitely prepare a problem for consciousness and, thus, for higher orders of thought.

## Visual Thinking is Real

There is a legitimate and distinctive mode of thinking that is visual. This is important to consider because computer graphics profoundly enhances our ability to think visually *en rapport* with the computer. Anecdotal evidence of inspirations resulting from visual thinking abound. A well-known instance concerns Friedrich Kedule's insight, in 1865, regarding the molecular structure of the chemical benzene — an inspiration that came in the form of a dream involving a snake biting its own tail. This mental image led Kekule to



the idea that the benzene molecule has a ring structure. Other scientists, including Albert Einstein, have commented on the importance of visual thinking in model building and in grappling with complex problems.

Although there are many anecdotal reports of the importance of visual thinking in science, the phenomenon has often been treated skeptically by experimental psychologists. In the late nineteenth and early twentieth centuries, psychologists became distrustful of all inner qualities of mind, since they could not be readily measured except by the self-reporting individual. Experimental psychology had been nearly crippled by too great a trust in introspection, and many experimental psychologists in the first decades of the present century rightly demanded more objective kinds of data. The behaviorists went so far as to banish all forms of self-reporting and introspection, even denying the reality of inner experience.

Fortunately, in recent years there has been a new focus on visual thinking among psychologists who have found more objective ways to measure it. Perhaps some of the most interesting information comes from neurophysiology, through Dr. Roger Sperry's work at the California Institute of Technology with epilepsy patients who have had to have the connection between the cerebral hemispheres, the right and left halves of the brain, cut to prevent chronic seizures. The two hemispheres are normally connected by a brain structure called the corpus callosum. When this structure is cut in neurosurgery, it is possible to present information exclusively to one hemisphere by, for example, limiting it to one half of the visual field. Generally speaking, in this situation, one hemisphere does not know what the other is doing. In this way, the different capacities of the two hemispheres can be compared. It is almost as though one person now has two independent minds.

The dominant hemisphere has proven to be better at mediating speaking, writing, and calculation. The non-dominant hemisphere is superior for visual tasks. If a line drawing of a cube is presented to the dominant, usually the left, hemisphere, the subject will find it difficult to draw an accurate copy. If it is presented to the non-dominant, usually the right hemisphere, the subject has little trouble copying despite the fact that the drawing is executed with the left hand, not normally used for such tasks. The non-dominant hemisphere is also superior at discriminating between items by touch and at matching tactile with visual stimuli.

Another experiment, conducted in 1960 by the Russian psychologist R. Natadze (reported in the United States by Stephen Kosslyn) should also be mentioned because it demonstrates how visual thinking can function as a substitute for real-world action.

This experiment simulates, using visual thinking, the conditions that produce the so-called weight contrast illusion. In the normal demonstration of weight contrast, subjects are asked to lift a very heavy weight with one hand and a light weight with the other. They are then given weights that are identical. In comparing the identical weights, they generally report that the hand that first held the heavier weight is now holding the lighter weight even though the second pair of weights are identical. Interestingly, Natadze's subjects found the same phenomenon when the entire experiment was *visualized in the mind of the subject*; that is, when no actual weights were manipulated.

Two findings are quite persistent in research on visual thinking. The first is that the way in which people think visually is different from individual to individual. The second important finding is that the degree to which individuals rely on visual thinking is, like almost every other measurable characteristic, distributed in the population. Some individuals think more visually than others.

An important aspect of visualization with the computer is that it tends to even out these differences among people. Why should it require a Kekule with an unusual gift for visualization to discover the molecular structure of benzene? Using a computer simulation, even a beginning student of chemistry might be able to deduce benzene's structure. Visualization need no longer be a solitary inner experience. The computer makes it possible for groups of individuals, even if they are separated by great distance, to collaborate in visual exploration whether in the artistic, design, or scientific spheres. The computer *democratizes* visual thinking. ●

*Richard Mark Friedhoff did his graduate work in psychology at Yale University and has been a consultant and writer on the subject of visualization since 1981. His highly acclaimed book* Visualization: The Second Computer Revolution *(Abrams, 1989) is the first to define visualization as an emerging field. He is currently Director of Planning for the Interactive Visualization Laboratory, a major new computing and imaging instrumentation facility at the University of California (Riverside) College of Engineering.*

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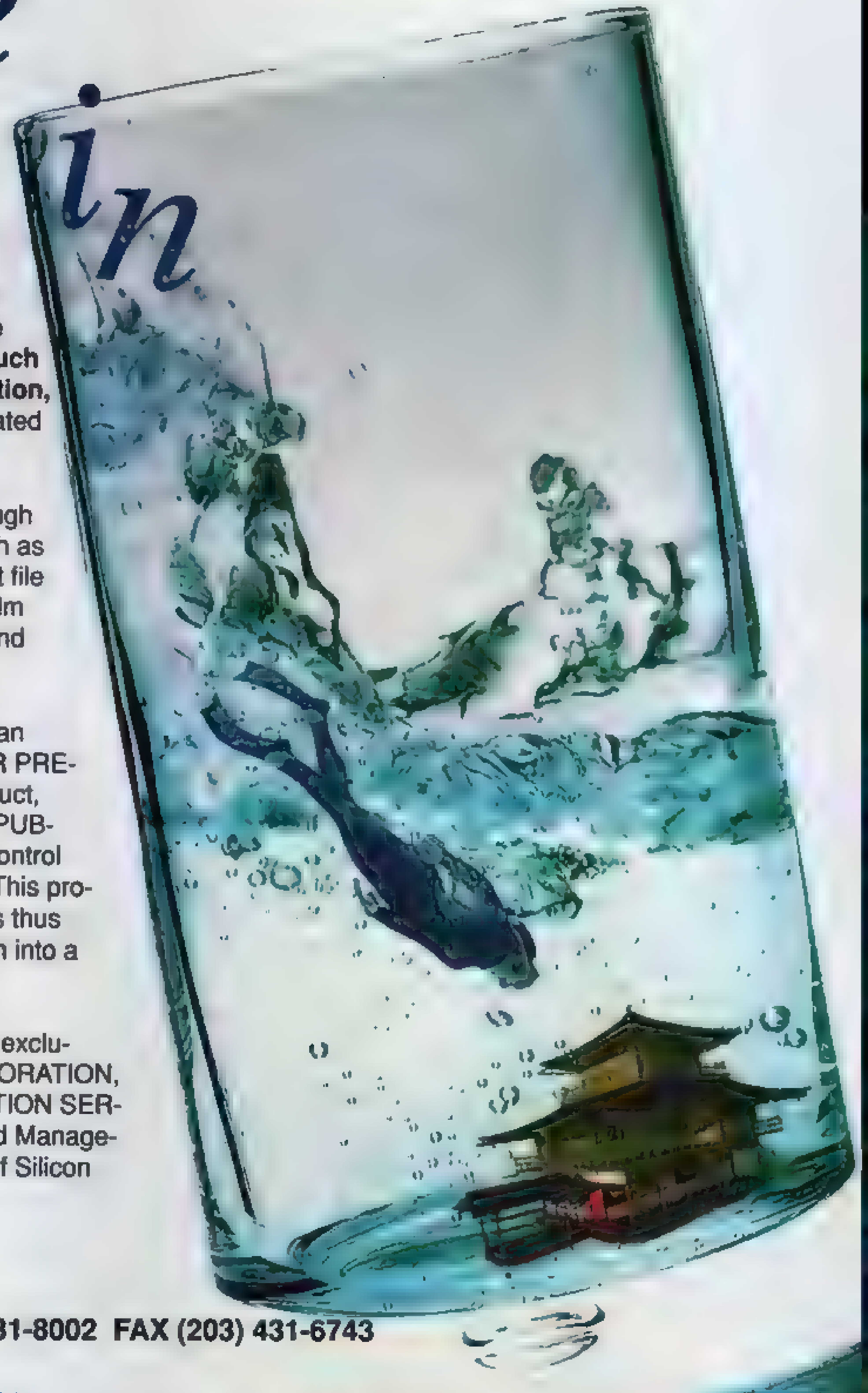

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# JOURNEY TO THE CENTER OF A SUPERNOVA

*The brightest explosion of a star to occur since the invention of the telescope provided scientists with many puzzles, a number of which are being solved using a Cray-2 and an IRIS-4D as a theorist's laboratory.*

BY DAVID ARNETT, BRUCE FRYXELL AND EWALD MULLER

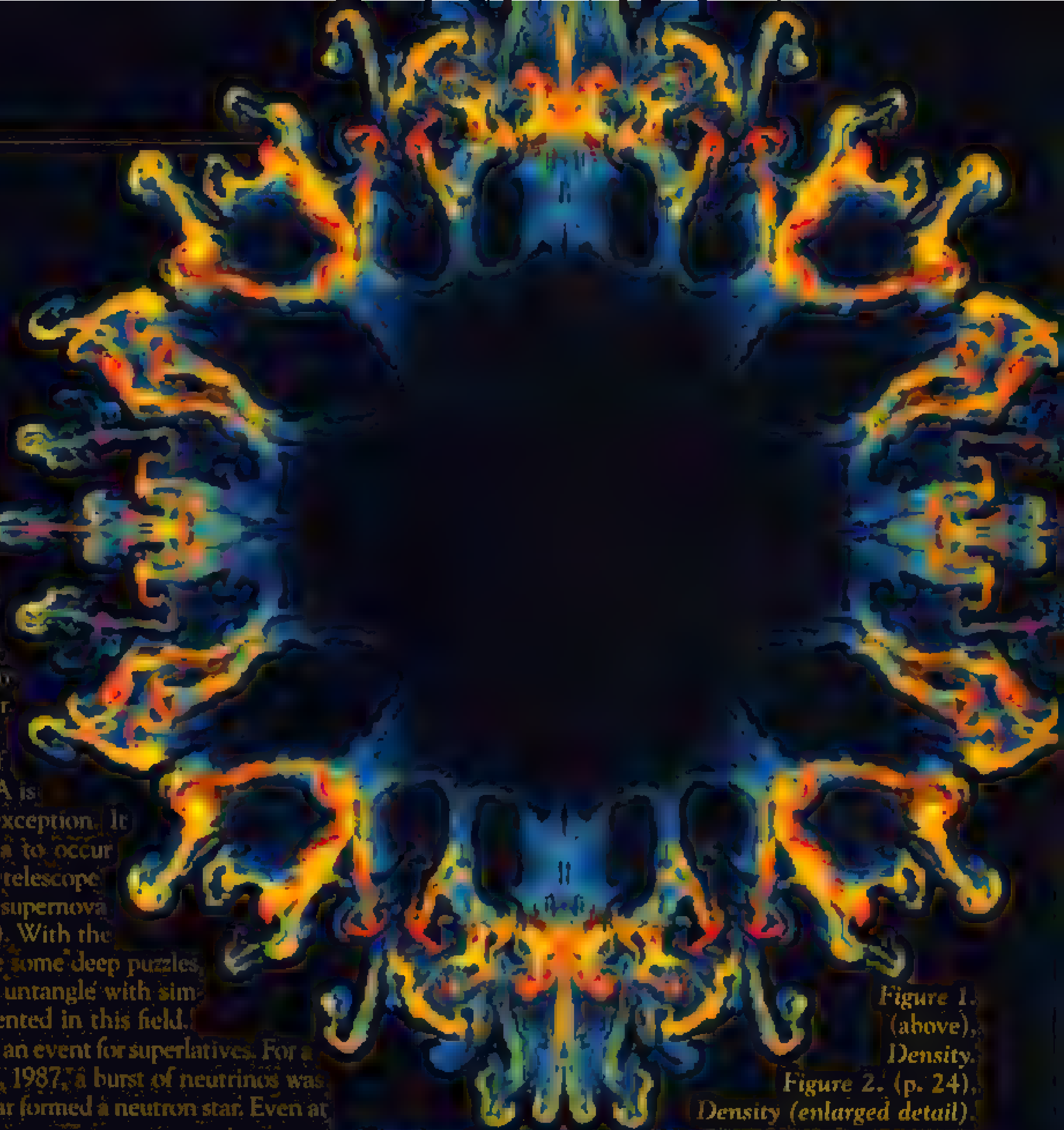

*Figure 1. (above), Density. Figure 2. (p. 24), Density (enlarged detail).*

Astronomy is a subject with an obvious appeal for computational simulation — we can't go there and look inside the things we wish to study. Observing them is hard and understanding them is harder. The recent explosion of a star in the Large Cloud of Magellan (Supernova 1987A is its official name) was no exception. It was the brightest supernova to occur since the invention of the telescope (we must go back to Kepler's supernova of 1604 to find one brighter). With the enormous flow of data came some deep puzzles, which we are beginning to untangle with simulations of detail unprecedented in this field.

Supernova 1987A was an event for superlatives. For a few seconds on February 23, 1987, a burst of neutrinos was released as the core of the star formed a neutron star. Even at a distance of 160,000 light years, so many neutrinos were released that about 10 billion ($10^{10}$) passed through the body of each adult on Earth. The interaction of neutrinos with matter is so weak that only one person in 10,000 suffered even one minuscule interaction. Sensitive instruments in Japan (Kamiokande) and Ohio (Irvine-Michigan-Brookhaven, IMB) detected a total of only 19 neutrinos, and these had already passed through the Earth (the Large Magellanic Cloud is in the southern hemisphere). This was the first experimental confirmation of an idea over fifty years old — neutrino emission from supernova.

Light from the explosion began to arrive about an hour later, the extra time being required for a shockwave to climb from the center of the dying star to its surface, causing heating and radiation. The earliest detections were on automatic equipment, being found in later examination of the records. Within a day there were optical identifications (the official discovery was by Ian Shelton at Las Campanas Observatory in Chile on a plate taken February 24.23 UT), and within a day and a half a battery of ground based and satellite instrumentation was focused on the new supernova. After the first two weeks, the ejected matter was heated predominantly by radioactive decay of nuclei synthesized by thermonuclear burning in the explosion. The supernova was detected in all electromagnetic frequency ranges, from radio to gamma ray.

## Puzzles Both False and Real

Any event as heavily observed as Supernova 1987A is likely to have its share of spurious results. Several claims of marginal detection of neutrino bursts, and of gravitational waves seem to be false. The very exciting detection of a rapidly rotating pulsar has been retracted; it was a false signal due to local causes.

There were a set of related observations which began to challenge interpretation early. About two weeks after the star's explosion, the interpretation of the spectra, which had worked quite well, seemed to demand a new source of heating near the apparent surface of the ejected matter. Later, in the fall of 1988, the Japanese satellite *Ginga* and the Soviet satellite *Mir* detected x-ray emission from Supernova 1987A, some 80 days earlier than expected. At about the same time the US *Solar Maximum Mission* detected gamma rays from the decay of radioactive $^{56}Co$, again earlier than predicted. Apparently some of the newly made radioactive matter was being mixed outward in the supernova ejecta in ways not expected.

A number of theories were advanced which were more notable for their imagination than for their plausibility. Much of the surprise had to do with our expectations; our conceptual framework was biased by the historical development of the subject. The theory of stellar evolution was built

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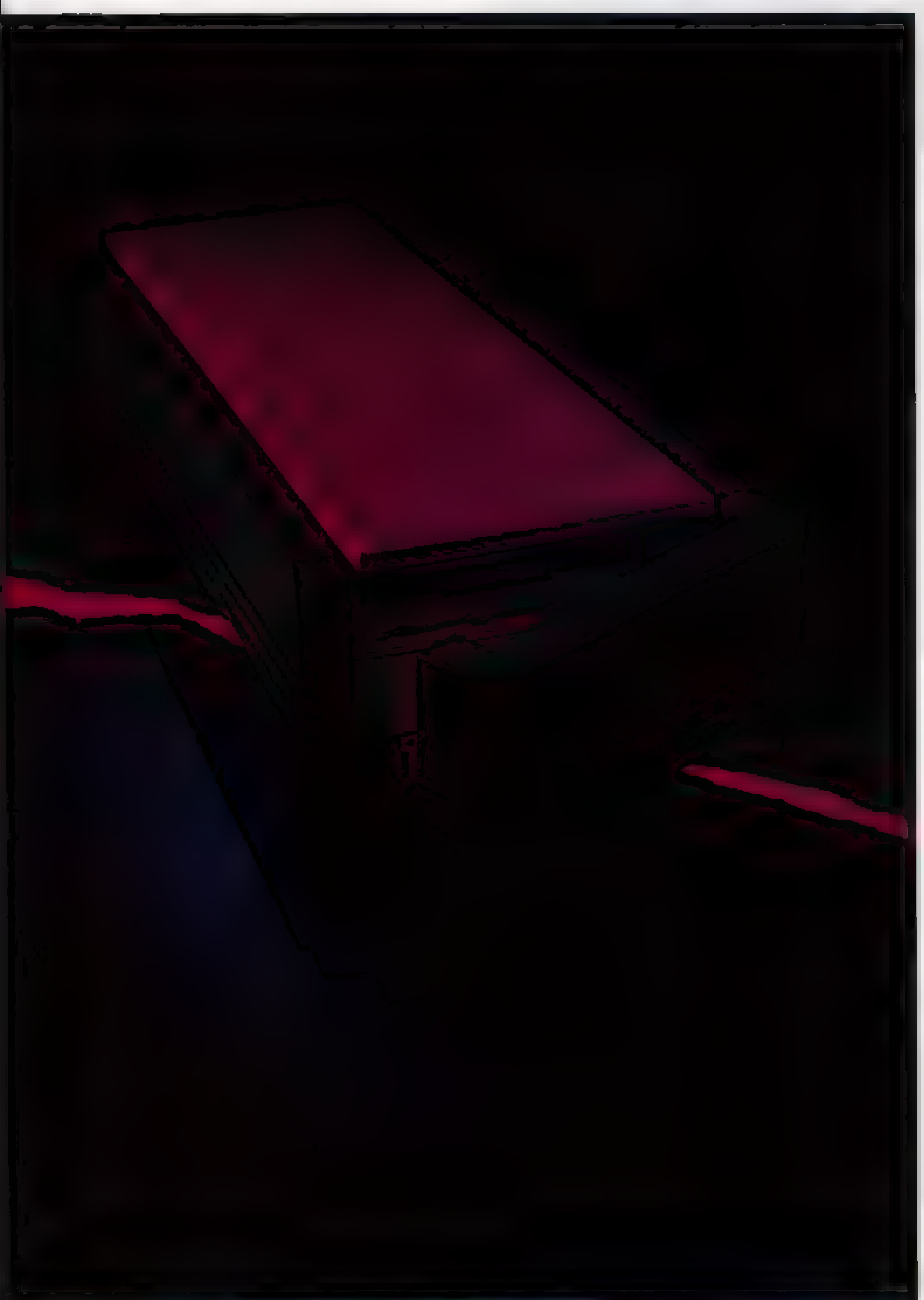

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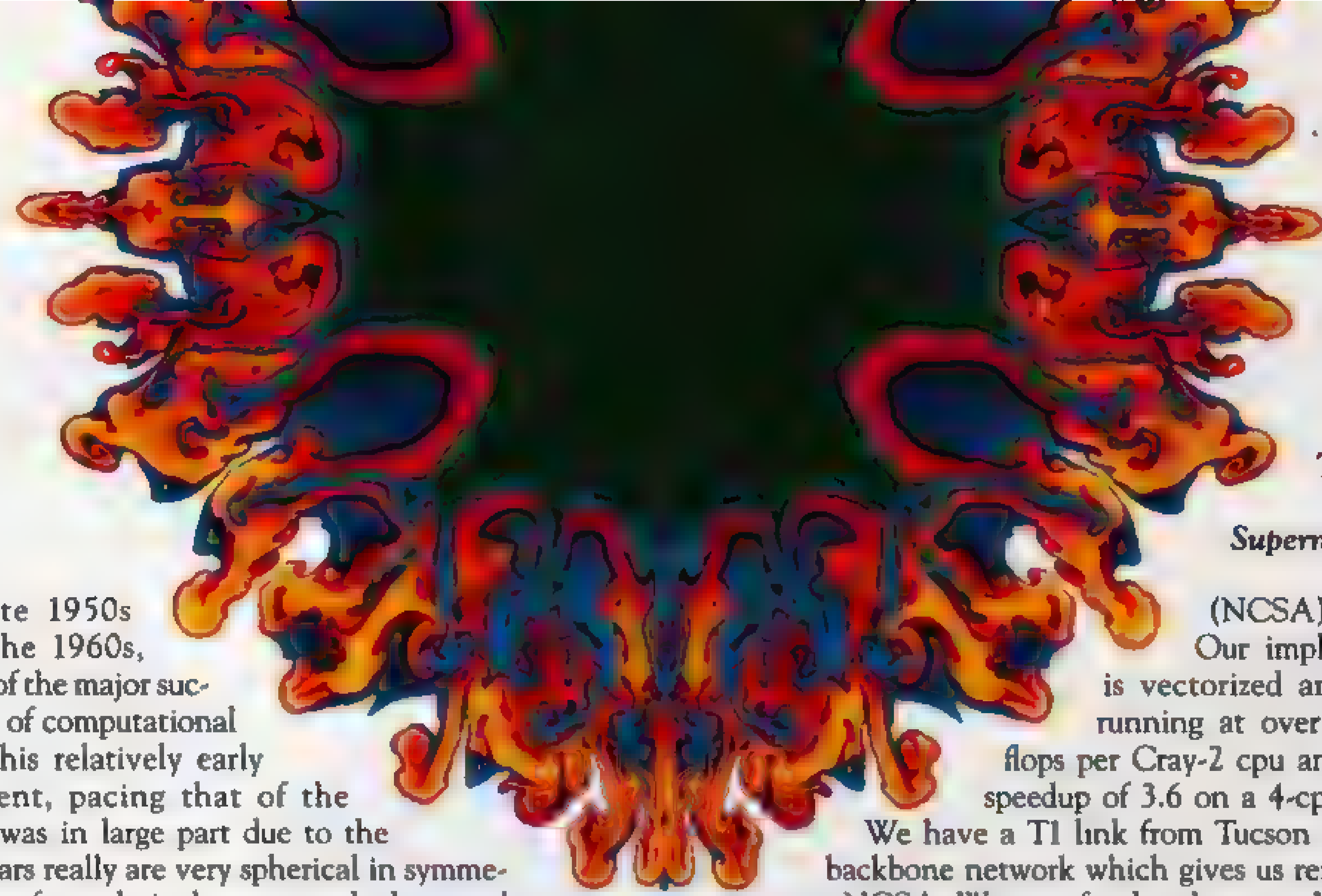

*Figure 3. The helium layer of Supernova 1987A*

in the late 1950s through the 1960s, and is one of the major success stories of computational science. This relatively early development, pacing that of the computer, was in large part due to the fact that stars really are very spherical in symmetry, and therefore relatively easy to calculate on the early machines. This symmetry is a consequence of two balances. The first involves self-gravity which pulls the mass together and a pressure gradient from center to surface which tends to resist compression. The second involves heat flow from hotter interior regions to the cooler surface, and energy release by nuclear burning or gravitational contraction. These balances act to give negative feedback to reduce nonspherical perturbations. While it is true that stars rotate and have magnetic fields (both of which should break the spherical symmetry), the net effect seems to be small.

During the 1970s and 1980s these spherically symmetric calculations were extended up to the point of collapse and explosion of stars, and became the foundation of our thinking on the subject. Still, there were worries that during an *explosive* event, this symmetry would break down; to this end preliminary work was done to simulate such events in 2D. This leisurely historical development changed to faster tempo with Supernova 1987A; it demanded we address a deceptively simple question: What would a spherically symmetric object provided by the theory of stellar evolution really look like if it exploded?

## The Tools We Use

The hydrodynamic algorithms are based on the "Piecewise Parabolic Method" (PPM) of Paul Woodward and Phil Colella, which provides a factor of $f = 2$ to 6 better resolution per computational element than any other method of which we know ($f = 6$ refers to a standard: the older and still popular method of Lax and Wendroff). Because the calculations are explicit, zone size affects time step, and 1, 2 and 3D calculations will run a factor of $f^2$, $f^3$, and $f^4$ faster if — as is true in our case — the time per step is dominated by computation of microphysics (equation of state, nuclear reactions, radiative transfer, etc.). Note that the factor $6^4 = 1296$ is more than the ratio of the speed of a Cray-2 cpu to than of a Vax 11/780.

Our calculations were run on Cray-2 supercomputers at the Rechenzentrum der Universitat Stuttgart (RUS) and the National Center for Supercomputing Applications (NCSA) at Urbana. Our implementation is vectorized and parallel, running at over 100 megaflops per Cray-2 cpu and having a speedup of 3.6 on a 4-cpu machine. We have a T1 link from Tucson to the NSF backbone network which gives us remote access to NCSA. We transfer data between Munich and Tucson by cartridge tape. A complete state at one instant in time, including velocities, thermodynamic variables and twelve compositions, requires 160 megabyte for a $1000^2$ grid; data compaction is important for us.

Our work cycle consists of a numerical experiment done on a supercomputer, with data transfer to our Silicon Graphics 4D/240 and 4D/20 for analysis. This allows us to monitor the results at intermediate stages of the computation. We wrote the graphics software using the SGI library. We have made extensive use of "memory movies', in which we store images of a time sequence in memory and replay it on the screen. This combination of tools, and especially the graphics capability, have allowed us to reduce significantly the time between the formulation of a numerical experiment and its analysis and publication.

## Simulating a Supernova

Figure 1 shows the density resulting from a simulation of Supernova 1987A. The calculations use a grid of $1000^2$ computational points in a quadrant, and assumed cylindrical symmetry. In this figure we have folded the quadrant into four, to give a sense of the entire object. This is 13,000 seconds (a little less than four hours) after the core of the star collapsed, and already the initial spherical symmetry is lost due to hydrodynamic instabilities. The "mushroom" features are characteristic of Rayleigh-Taylor instability, and the wavy features of Kelvin-Helmholtz. These may be seen more clearly in Figure 2.

The presupernova star is predicted to have an "onion-skin" layering of shells of different composition. Figure 3 shows how a representative layer, that composed primarily of $^4He$, is corrugated and broken by this early time. The nature of this mixing is consistent with that implied by the early escape of gamma rays and x-rays mentioned above.

Figure 4 shows the position of strong shocks (turquoise) and weak shocks (yellow). This complex structure indicates the need for excellent resolution in the simulation. The weak shocks result from the nonlinear interactions of the "mushrooms". The strong shock is reverse shock caused

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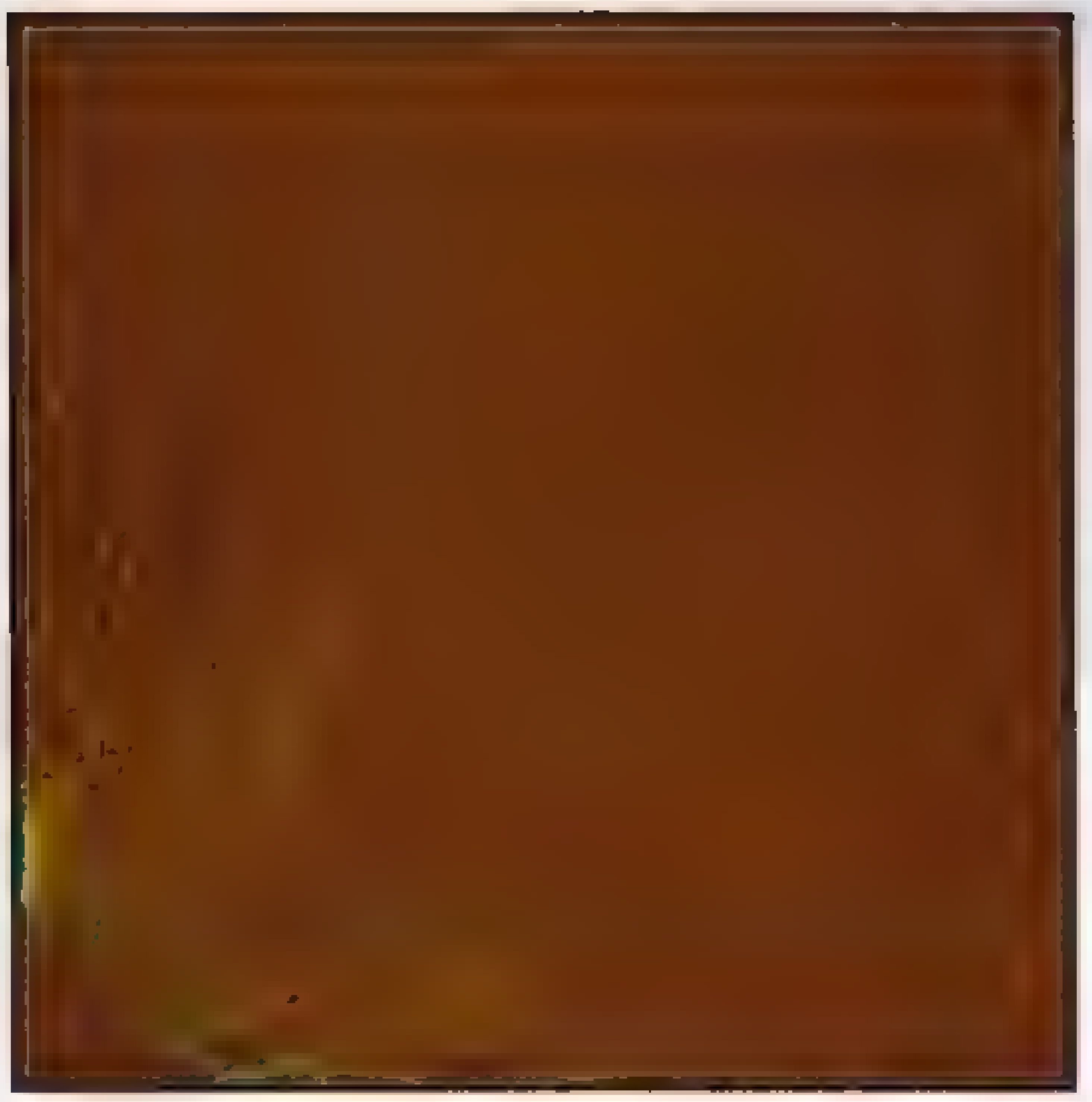
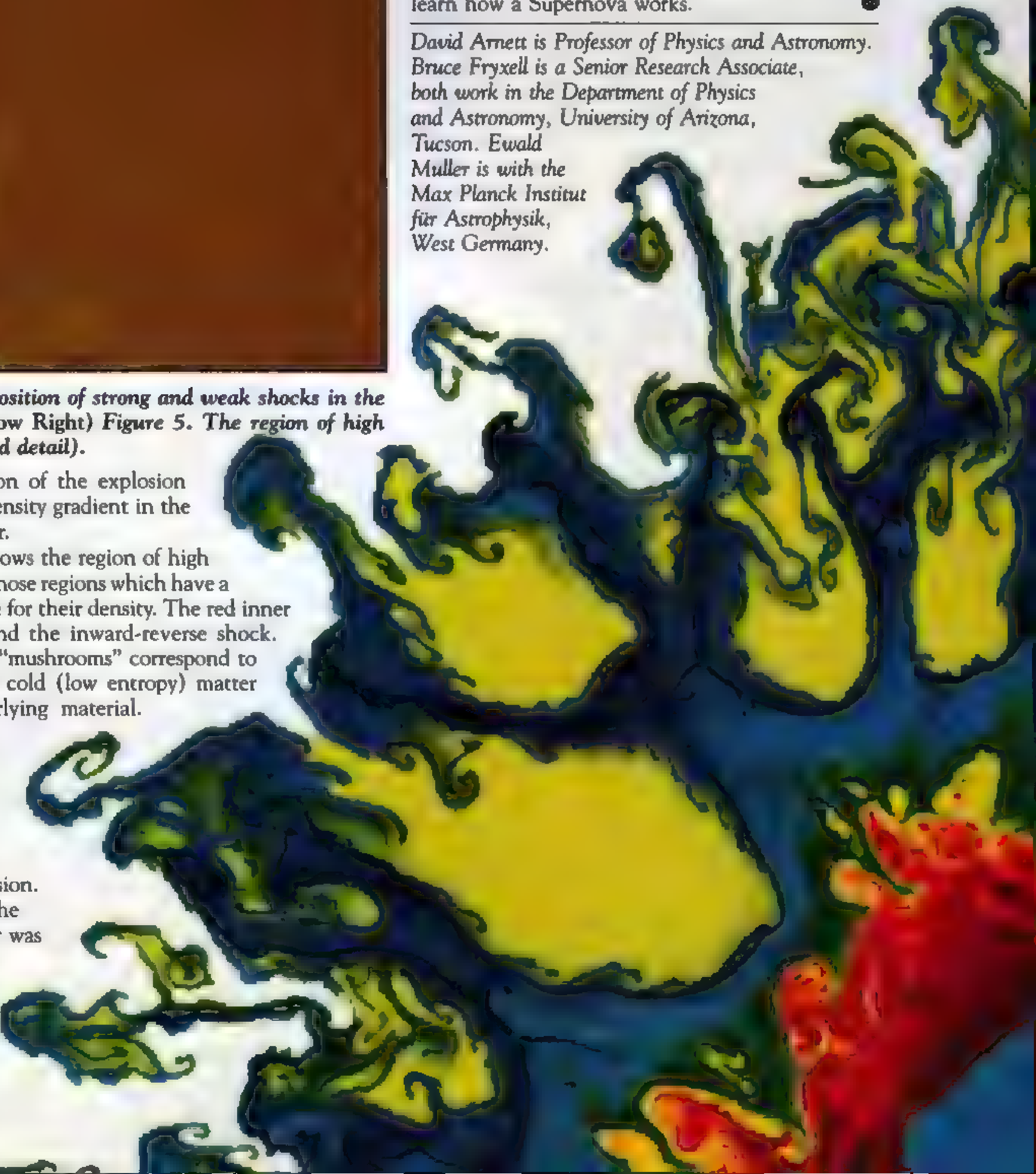


***Figure 4. The position of strong and weak shocks in the supernova.* (Below Right) *Figure 5. The region of high entropy (enlarged detail).***



by the interaction of the explosion with the steep density gradient in the presupernova star.

Figure 5 shows the region of high entropy, that is, those regions which have a high temperature for their density. The red inner region lies behind the inward-reverse shock. Notice that the "mushrooms" correspond to dense, relatively cold (low entropy) matter penetrating overlying material.

These results represent theoretical predictions for the early development of the supernova explosion. At the time of the event the matter was opaque to radiation, so that we could not directly observe its behavior. Now it is transparent, and with high resolution instruments (such as the Hubble Space Telescope) we should be able to compare our predictions with reality. By looking at spectral line emission, we can determine the composition, the velocity component along the line of sight, and the position of matter in Supernova 1987A, and with the aide of computer simulations, learn how a Supernova works.

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*David Arnett is Professor of Physics and Astronomy. Bruce Fryxell is a Senior Research Associate, both work in the Department of Physics and Astronomy, University of Arizona, Tucson. Ewald Muller is with the Max Planck Institut für Astrophysik, West Germany.*

# FDDI THE MAGIC RING

*The Fiber Distributed Data Interface, the next evolutionary step in the communications infrastructure, may prove to be as significant to the United States as its national highway system.*

BY PAULINA BORSOOK

It's no secret that computers and networks are getting faster and faster. A low-speed (1.2 kbit/s) network of ten years ago looks little like a low-speed (1.544 Mbit/s) network in 1990. Applications are relying more and more heavily on bit-heavy graphics, sending their multicast images and data to many different locations at the same time. Local Area Networks (LANs) continue to proliferate and at the same time need to talk to each other.

Rich Stohr, technical director for U.S. West Advanced Technologies (Englewood, Colorado) points out that the increasing speed of workstations, size of memories, power of processors, and numbers of pixels act as "drivers, that will each grow more than a couple of orders of magnitude over the next ten years. The demand for information transport never stops growing."

Yet with all these increasing demands for more speed, power, and interconnection in computers and communications, system reliability tops the wish list for most network administrators. The solution to this paradoxical set of complex demands may lie with a single technology, Fiber Distributed Data Interface (FDDI).

FDDI is a 100 Mbit/s standard for fiber-optic communications made up of two counter-rotating rings of message traffic. FDDI supports distances of up to 200 kilometers with up to 2 kilometers between stations; by contrast, the ideal maximum throughput for contemporary Ethernets is 10 Mbit/s over a range of a few kilometers. Through an ingenious method of error detection and correction (see sidebar "Getting Around The Ring"), FDDI networks have a built-in self healing capacity capable of isolating faults while maintaining network operations. If a link failure occurs, a normally idle secondary ring comes into operation, demonstrating the fault-tolerance of the network. The use of fiber itself protects against noise and its attendant errors.

FDDI may be part of a larger push towards boosting American competitiveness and technological innovation. By offering a standard means to deploy high-speed fiber both locally and long-distance, it could be integral to what Alan Huang, the Bell Laboratories' researcher who invented the first working optical computer, terms "a national sense of mission." FDDI and fiber could do more than foster critical technical innovations along the lines of High-Definition Television (HDTV) — they could be "the next step in the communications path the U.S. has been evolving on, from the Panama Canal to the advent of universal telephone service. Fiber to the home could be like the building of the national highway system." Huang sees another more useful, if somewhat prosaic, potential benefit in fiber to the home: it could create "an infrastructure that can't be taken out of the country or sold."

Developed as an ANSI standard, high-speed, highly-reliable FDDI was first conceived of as a backbone network connecting LANs and mainframes. While FDDI is already being used this way in high-tech companies such as Microsoft (Bellingham, Wash.), there are other, more ambitious uses for the technology.

According to Silicon Graphics product marketing manager for high-speed networking, Marty Palka, FDDI is a good fit for visualizing the massive amount of data a Cray-sized supercomputer cranks out while calculating the Computational Fluid Dynamics (CFD) involved in the simulation testing of a new airplane wing or the mathematical modeling of the lifespan of a thunderhead.

Palka says that with "FDDI's performance, reliability, and support for communications over increased distances, new applications, impossible with slower networking technology, will now be possible." For example, every aspect of network performance itself could be modeled and monitored using distributed visual processing. In another example, networks with diskless nodes might become a good solution for networked managers who wanted better control over information. By putting information on a shared server instead of on each individual machine, administrators would be better able to manage overall network functions. In the past, network managers have often shied away from diskless setups because the speeds involved in accessing a remote disk

### ND THE RING GETTING AROUND THE RING GETTING AR

Like any new technology, FDDI has its own set of buzzwords and acronyms. Here's a quick-guide to some of them.

**4B/5B** Data-encoding scheme that maps four bits of data into a five-bit code. The scheme insures sufficient bit-transitions to maintain clock synchronization.

**Beaconing** Fault detection technique. When a station's MAC decides there is a problem on the network, it goes into ring recovery where it sends out a special beacon frame. The beacon frame is passed along by the other stations in the ring who defer their own transmissions on receipt of the beacon frame. When there is a problem on the ring, every station eventually stops transmitting except for the beacon frame originated by the station just downstream of the fault. In this way, the fault can be isolated and ring operation can be restored.

**Bypass** The capacity of FDDI nodes to optically isolate themselves on an FDDI ring without affecting the network's operation.

**Claim Process** The method used by stations on an FDDI ring to bid for the right to issue the token.

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were far greater than those involved in accessing a local disk. But the combination of higher-speed workstations operating over higher-speed FDDI networks would make diskless configurations a realistic and useful option.

Palka further believes that any distributed visual application, from hospital-wide transmission of digitized cross-sections of human tissue to the bar graphs and monitors needed to manage a live network, lends itself to FDDI. U.S. West's Stohr, concurs, for he already has customers in his service area that cannot get the bandwidth they need through existing networks. "At Los Alamos, they have a three-dimensional CAD/CAM application derived from data taken from a supercomputer. They need gigibits to the workstation and they need gigabits to transfer files."

Bill Sykes, division marketing manager for network products at FDDI chip-manufacturer AMD (Sunnyvale, California) envisions digitized document storage and retrieval, sought after by government agencies and insurance companies in their quest to reduce paper and increase efficiency, as another likely use for FDDI's bandwidth and

ND THE RING GETTING AROUND THE RING GETTING AR

Bidding with a claim frame (which contains no data) is done every time a new station enters the ring and every time a problem in the network causes a token to be lost. Claim frames are used to determine which station's TRTT has priority on the network. The station whose claim frame indicates that it has the lowest TRTT wins the claim process to use the token.

**HRC - Hybrid Ring Control** Data Link Layer capacity that multiplexes both circuit- and packet-switched data. Known informally as FDDI II, HRC is a draft standard for multiplexing FDDI networks onto the same fiber as other technologies such as voice or video. HRC stipulates speeds of 100 Mbit/s or greater over distances larger than several kilometers.

**MAC - Media Access Controller** A sublayer of OSI Data Link layer, MAC determines packet-formation, network addressing, and Cyclic Redundency Check (CRC) error correction. MAC is responsible for the scheduling, routing, and transmission of frames and tokens. MAC performs claims processing and beaconing.

**MIC - Media Interface Connector** Consisting of a plug and a receptacle, this mated connector pair attaches an FDDI node to fiber optic cable.

reliability. Sykes comments that "people are saying that multimedia applications that integrate voice, data, and video are the wave of the future. The bandwidth needed for these are way beyond what Ethernet and Token-Ring can offer." FDDI may finally make possible the futuristic applications exemplified by groupware and microcomputer-to-microcomputer remote videoconferencing.

And as for Ethernet, the defacto industry-standard for networking, computers and computer memories are ten times faster than when it was invented ten years ago. Silicon Graphics' member of technical staff, Vernon Schryver, points out that "not only can a single Auspex network concentrator on the market today saturate eight Ethernets simultaneously, two Silicon Graphics IRIS workstations by themselves can saturate one Ethernet with files and raw computer data alone." AMD's Sykes explains that "by 1992, leading manufacturers of workstations will be turning out machines that will overwhelm an Ethernet or Token-Ring on a station-to-station basis."

A computer user already impatient for FDDI is Bill Chimiak, instructor on the research staff in the department of radiology at the Bowman-Gray School of Medicine at Wake Forest University (Winston-Salem, North Carolina). Chimiak is responsible for the department's picture archival and communications system (PACS) network for all radiology images: computer-aided tomography (CAT scans), magnetic-resonance imaging (MRI), nuclear-medical imaging (NMI), positron emmision) (PET), ultrasound, and conventional X-ray, Using FDDI as part of his strategy, Chimiak's goal is to make the department totally filmless, relying on optical jukeboxes for image storage.

Chimiak wants to do more than make it possible for several doctors to be able to look at the same image at the same time, manipulating what they see with mouse pointers through advanced distributed technologies typified by Xwindows. He wants images to be sent to archives at the same time they are called up for viewing. What's more, by making use of FDDI's long-distance as well as local capabilities, he plans to have Bowman-Gray's network hooked up with the statewide 45 Mbit/s T3 network sponsored by the state of

**ROUND RING GETTING AROUND THE RING GETTING AROUND THE RING GETTING AROUND THE RING GETTING AR**

**PHY - Physical Layer Components** One of two sublayers of an OSI Physical Layer, PHY specifies FDDI's 125 Mhz clock frequency and the technique for recovering incoming information from an upstream neighboring station. It also dictates how 4B/5B data and control signals are represented on the network and specifies retiming of the data in the node's internal clock.

**PMD - Physical Layer, Medium-Dependent Sublayer** One of two sublayers of an OSI Physical Layer. PMD specifies the optical characteristics of FDDI equipment, including wavelengths for optical transmission, fiber-optic connections, cabling, and an optical bypass switch.

**SMT - Station Management** The SMT draft standard is expected to become finalized by the end of 1991; it defines error detection plus fault isolation and correction. SMT also details how stations are to be added onto and taken away from the network, and is connected to the PHY, PMD, and MAC sublayers. SMT algorithms are responsible for overall network fault detection and define how the FDDI network should respond to error conditions.

**THT - Token-Holding Timer** An internal timer that measures the time a station holds the token while sending asynchronous packets.

**Token** A frame with a special format passed around a network that determines which station is allowed to transmit. A station must hold the token in order to transmit. A station must give up the token after a predetermined amount of time or when it no longer has data to transmit, whichever happens first.

**TRT - Token-Rotation Timer** An internal timer that measures the time between receipt of tokens, TRT expires when it exceeds a TRTT.

**TTRT - Target Token-Rotation Time** Making up the four bytes of the information field in a claims-process frame. TTRT refers to the amount of time a station bids in the claims process. A station's TTRT usually has a default value, but can be set by a network administrator. The station whose claim indicates that it has the lowest TTRT wins the claims process. This TTRT value is then used by all stations on the networking for setting TTRT.

**X3T9.5 - The American National Standards Institute (ANSI)** The committee responsible for the creation of the FDDI standard.

## XTP: PROTOCOL LITE

XTP is a protocol designed to reduce communications and host overhead and take advantage of ever-increasing hardware speeds. First proposed by engineers at Silicon Graphics, the protocol is now in the process of becoming an official ANSI standard through the suspices of ANSI committee X3S3.3. The committee has within it the HSP (High-Speed Protocol) working group charged with developing protocols such as XTP that will be able to meet the demands of increasingly-speedy networks and ever-more-powerful computers. Larry Green, president of Silicon Graphics' joint venture partner, Protocol Engines Inc. (Santa Barbara, CA.), is chair of HSP.

Government agencies such as NSWC (Navel Surface Weapons Center) and NOSC (Naval Oceanic Systems Center) are participating in XTP development, as are schools such as the University of Virginia. The Navy has specified the protocol for its Safenet (Surviveable Fiber Optic Embedded Network) standard. Chip-level manufacturers Intel and AMD are involved, as are board-level manufacturers Interface Corp. and DY-4. Among the computer vendors contributing to the creation of the new protocol are IBM, Apollo, and Xerox.

Some time in the next year, XTP will be appearing in chip form, manufactured by PEI. Implementing XTP in silicon rather than leaving it in software fits with the philosophy of Silicon Graphics' Greg Chesson, one of the developers of the new protocol. To Chesson, it was important to develop a protocol simple and elegant enough that it could be easily implemented in silicon. XTP's approach of incorporating software functions in hardware is similar to that of Silicon Graphics' Geometry Engine, where instructions go directly from an application to computer microcode, bypassing the operating system. Embodying XTP in hardware form will bring down the cost of using the new protocol and will capitalize on its potential for making networks work more efficiently.

Silicon Graphics' Marty Palka says that a software version of XTP will be available within the year for implementors to experiment with and that the silicon version should be available some time in the middle of 1991.

Protocol Engines' chip-form XTP will offer IEEE 802.2 Logical Link Control services, making it possible for XTP to connect with chips that implement existing MAC-level standards. XTP will thus be able to peacefully coexist with other protocol stacks and be able to use extant network addressing formats. The

North Carolina's Microelectronics Corporation. With an average MRI image requiring 40 Mbytes of data, Chimiak needs the full FDDI 100 Mbit/s to move the images around his network.

Chimiak's current network operates point-to-point and Chimiak says that "it is already running out of ports. With an FDDI star configuration, that won't happen so easily." On the proprietary part-digital/part-hybrid network he has now, "20 doctors want to look at images, but there are only three viewing stations. With FDDI, we'll be able to have FDDI-transported images sent around at FDDI speeds to every port." Chimiak is also looking forward to replacing his proprietary network with ANSI-standard FDDI equipment. "With an open network, you can get more applications. As is usually the case with standards-based networking, you can make more things happen more cheaply." ANSI-standard equipment will improve the interoperability of Chimiak's network.

However, existing network software and protocols may not be able to take full advantage of FDDI. While Transport Control Protocol/Internet Protocol (TCP/IP) can be expected to have higher throughput over FDDI than it has over Ethernet, this may not be adequate to the tasks FDDI users will be demanding of it. Furthermore, it took many years for the data communications industry to optimize TCP/IP over Ethernet, and achieving the theoretical maximum throughput of FDDI will take similarly long development effort. Research on protocols that can work with the higher-speeds and point-to-multipoint multicasts of FDDI and other zippy new technologies like Broadband Integrated Services Digital Network (ISDN), Synchronous Optical GL, and Networks (SONET), and Metropolitan Area Networks (MANs) has lead to the creation of Xpress Transfer Protocol (XTP) (see sidebar "XTP: Protocol Lite").

Silicon Graphics' chief scientist Greg Chesson, one of the originators of XTP, wanted to do something about the inefficiencies of networking, having in mind the theoretical ideal of reducing communications-processing overhead to

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new protocol's flexible addressing methods will give XTP implementors the option of using their own addressing formats.

XTP uses a variety of techniques to reduce network-processing overhead. For one, XTP implemented in hardware can process packets back-to-back in realtime, so that the time it takes to process a packet does not interfere with the flow of packets. With conventional transport-level protocols Internet TCP or OSI TP4, the time it takes to process one packet can actually take longer than the time it takes for the next packet to arrive and so hinder the movement of network traffic.

XTP is intended to work with simultaneous circuits on a network, providing the true distributed processing necessary to the complex mesh networks of the 1990's. With the XTP design philosophy of keeping network overhead down, the connectionless datagram-style new protocol handles multicast transmissions in a unique fashion.

With XTP, a flagged first packet indicates to the network that a multicast transmission is on its way so that members of the multicast group can open a connection. If the receiver of one of these multicast transmissions detects a lost or corrupted packet, it will multicast the sequence number of the lost packet, notifying all receivers of the messed-up data. Because an error message is sent only if a sequence number lower than that specified in already-received error messages is detected, only one error message is necessary to recover the errant packet, saving on network bandwidth.

Another part of XTP's overhead-lightening scheme consists of its support for fixed-length control fields. This means that instead of examining an entire frame full of data to see where the control information leaves off and the actual message contents begins a node on a network can easily separate message data from control information. Messages can then be routed to their destinations more quickly. Carrying control information in a fixed place saves computers the task of sorting through a large transmission in the effort to find it.

To make XTP's protocol-processing demands even more lightweight, in an XTP packet, error-recovery algorithms such as checksums are located at the end of a preceding packet. With conventional protocols, they reside at the beginning of the packet itself. Changing the location of checksums and such speeds up data transmission.

zero. XTP represents an effort to make network protocols fit better with their underlying hardware, so that FDDI and other high-speed networks can be used to their full potential.

As for when users of computers and networks should be expecting FDDI, market-research firm Forrester Research (Cambridge, Mass.), predicts that "in 1990, every major vendor will announce plans for supporting FDDI." Dataquest, the San Jose, California market research firm believes that by the end of 1990, 7,000 FDDI nodes will be shipped, followed by 25,000 in 1991, and 340,000 in 1992. Both Forrester and Sykes think that backbone LAN implementations will commonly start to appear by 1991, and that by 1992, low-cost microcomputer attachments to FDDI rings will be on the market, causing the proliferation of distributed visual-processing applications.

When it comes to actually implementing FDDI, the fiber already installed for Ethernets may be useable with the dual rings. Users may want to go with a cheaper version of FDDI, attaching workstations in a single-, as opposed to dual-, ring topology through an FDDI concentrator. To smooth the migration path to FDDI, vendors are already gearing up with plans to develop Ethernet-to-FDDI converters.

Silicon Graphics will announce its FDDI product in the summer of 1990. The product will support both TCP/IP and DGL, and will be available across SGI's 4D product line. The system will provide single Mac dual-attach capabilities, and by simultaneously supporting both Ethernet and FDDI, will be able to act as a router.

Given the current state of networking and throughputs, "You can send an image around a network," SGI's Palka explains, " but with FDDI, you can send a movie."

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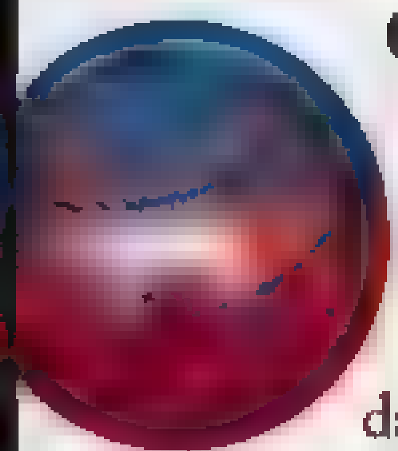
*Paulina Borsook is the former West Coast editor of* Data Communications *magazine. Ms. Borsook, now a freelance writer specializing in computers and communications, is currently pursuing a Master of Arts degree in fiction at Columbia University.*

# COMMUNITY FORUM

## Multimedia Conference Coming to Singapore



Singapore is the location, January 16-18, 1991 the dates, for the International Conference on Multimedia Integration. The get together will serve as a forum for the exchange of ideas on the next generation of computer tools and applications. Discussions will explore the creation of systems that integrate computer, publishing, printing, video and movie technology.

For conference information, contact: Prof. Stavros Christodoulakis, Institute for Computer Research, University of Waterloo, Waterloo, Ontario, Canada N2L 3G1, (519) 885-1208 FAX or (Bitnet) Watmath! WatDaisy!Schrisodoul @uunet.uu.net.

## CyberArts International

*Keyboard* and *EQ* magazines are presenting the first professional conference and performance showcase of emerging and multimedia technologies as they apply to the arts. The event will be held September 6-9, 1990 at the Biltmore Hotel in Los Angeles. It will feature live performances, hands-on training, a CyberArt Gallery, product exhibits, and conference presentations. Speakers include: Chick Corea, George Coates, Andy Moorer, Mark Cantor, Brian Eno, Myron Kruger, Jaron Lanier, Hans Zimmer, Robert Moog, and Bill Buxton.

For more information, contact: Bob Gelman, CyberArts International, Miller Freeman Expositions, 500 Howard Street, San Francisco, CA 94105, (415) 267-7646 or FAX (415) 995-2494.

## 19th Annual Meeting of the ICPP

This year's International Conference on Parallel Processing sponsored by Pennsylvania State University will be held August 13-17 in St. Charles, Illinois. For more information, contact: T.S. Feng, 121 EEE Bldg., Pennsylvania State University, University Park, Pennsylvania 16802, (814) 863-1469.

## Visualization '90

Visualization '90 takes place October 23-26 in San Francisco, California. The meeting will explore how visualization is being used to extract knowledge from data. While the focus is on all aspects of visualization as applied in science, engineering, and business, special attention will be paid to interdisciplinary techniques.

For more information, contact Val Watson at (415) 604-6421. The conference is sponsored by IEEE Computer Society, Technical Committee on Computer Graphics.

## British Computer Society will Host INTERACT '90

Researchers and practitioners interested in the study of human-computer interaction (HCI) will come together in Cambridge, England August 27-31, 1990. The meeting will provide delegates with an opportunity to share current HCI knowledge and research about the design, implementation, usage, and evaluation of computer systems.

For more information, contact: Karyn McCartney, INTERACT '90, The British Computer Society (BISL), 13 Mansfield Street, London W1M 0BP, UK, +44 (0)1 637-0471 or +44 (0) 631 1049 FAX.

## AUSGRAPH '90 to be in Melbourne

The seventh annual Conference of the Australian Computer Graphic Association, AUSGRAPH '90, will be held September 10-14, 1990 in Melbourne, Australia. The Arts Stream of the conference will include paper presentations, artwork, and installations for an international exhibition of art and technology, as well as animations and digital video for the National Art and Animation Competitions.

For conference information, contact: AUSGRAPH '90 Secretariat, P.O. Box 29, Parkville, VIC 3052, Australia, (03) 819-8124 or (03) 810-5454 FAX.

*The images on this page were created by David Tristram.*

*Please send submissions to Community Forum to* IRIS Universe, *Mail Stop 415, Silicon Graphics, Inc., 2011 N. Shoreline Blvd., Mountain View, California 94043.*

# PRODUCT BRIEFING

## Graphical Modeling for the Fortune 500

Several Fortune 500 companies have chosen SL Corporation's GMS development system for building and managing graphics screens which can be embedded in applications. Specific application areas include manufacturing and process control, network management, avionics and cockpit display, financial analysis and trading, and any application requiring integration. SL-GMS supports many platforms, including all IRIS workstations running under UNIX System-Vbsd (SGI version 3.1) and IRIS-GL.

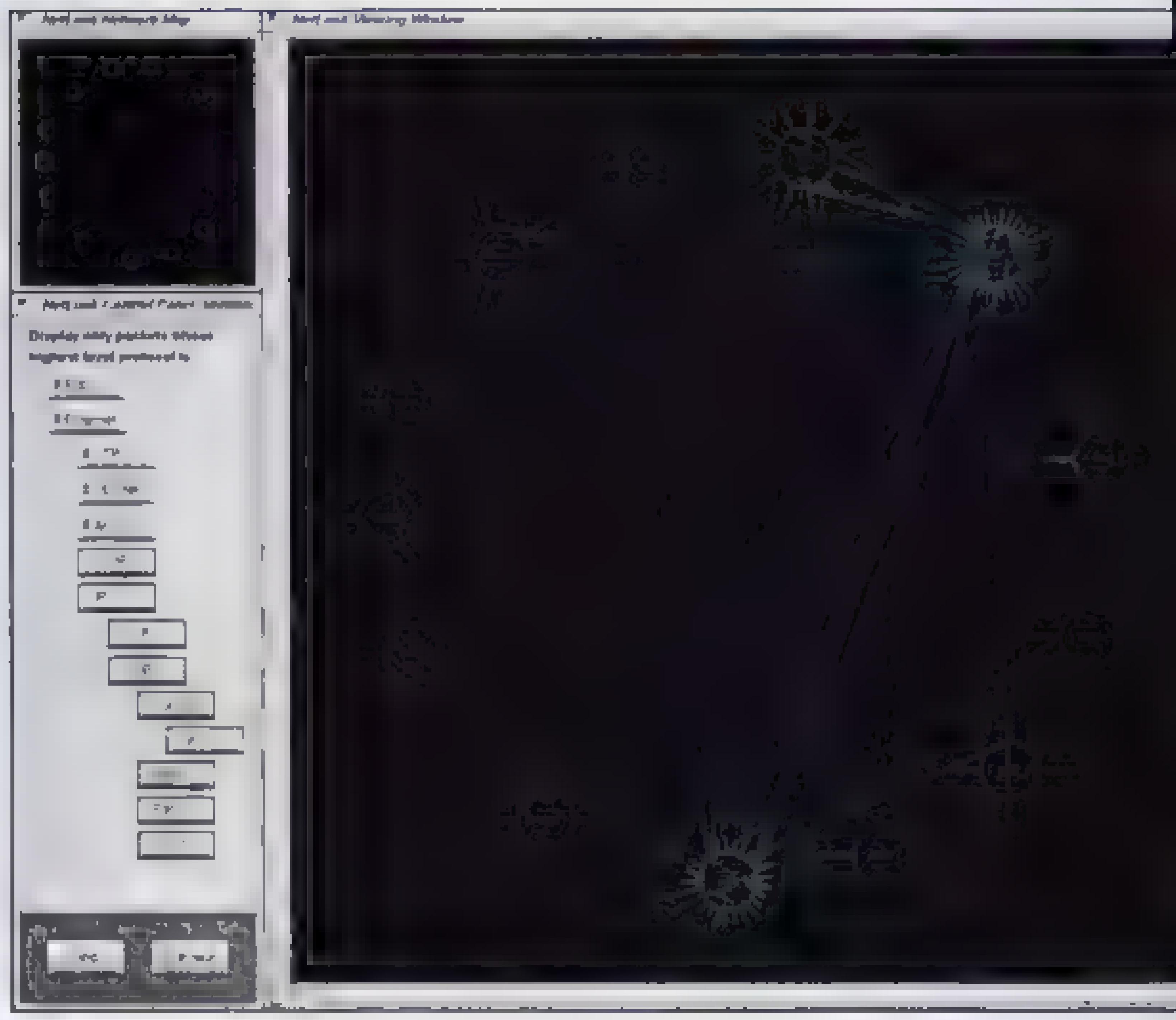
The SL-GMS features mouse driven drawing tools to design portable application interfaces. Previously, developers wishing to customize vendor-supplied graphical objects and behaviors needed to resort to raw coding.

For more information, contact: Christopher Wilson, SL Corporation, Corte Madera, California, (415) 927-1724.

## Real-time Visualization for Network Administration

Silicon Graphics has announced NetVisualyzer™, the first network monitoring and diagnostic tool in the industry to offer real-time visual feedback of network configuration and traffic analysis. Using visual processing technology to make complex network information easy to understand, NetVisualyzer's monitoring and diagnostic functions help network managers reduce network downtime, lower network operating cost, monitor network security, and optimize network designs. Also standard with the product are traditional network and protocol analyzer capabilities, which are useful for developers of network-based applications. All tools come with a graphical and point-and-click user interface.

Two IRIS-based NetVisualyzer configurations, the Display Station and the Data Station, are designed to help network managers centralize monitoring and control of distributed networks. Built-in support for all Ethernet- and FDDI-based protocols is especially useful in a multi-vendor, multi-protocol network environment. NetVisualyzer is the first in a series of network management tools that will include support for industry standards such as Simple Network Management Protocol (SNMP).



For more information contact: Larry Kung, Silicon Graphics, (415) 335-1496.

## StereoView for the *Personal IRIS*

Silicon Graphics' StereoView™ option is now available for the Personal IRIS. StereoView enhances viewing of complex data by providing greater depth perception for images on the workstation monitor. This will be of great benefit to users such as research chemists wishing to explore complex 3-D molecular design data. Previously available only on the IRIS POWER Series™, StereoView will now be available to a broader range of technical users. StereoView is a factory installed option.

For more information, contact: Greg Cook, Silicon Graphics, (415) 335-1151.

## WORK-OUT from Comutec

WORK-OUT is a 3D graphical software package for workcell modeling and simulation. Its advantages include an interactive model editor to allow quick changes of the layouts and workcells in the factory, a robot program debugger, internal data storage which is fully conformant with the PHIGS+ standard, and the abillity to

import files from other graphical databases.

For more information, contact: Mark Ludwig, Comutec, Troy, New York, (518) 276-2817.

### Meet FRED from OptiMetrics

OptiMetrics, Inc. has introduced the Faceted Region EDitor (FRED) code, a package designed to make tedious operations involved in preparing a vehicle for thermal modeling much easier. It runs on any IRIS 4D workstation.

FRED is a major component of an end-to-end vehicle modeling capability incorporating CAD packages, thermal models, atmospheric and sensor models, and hardware-in-the-loop simulations. The program can create and manipulate faceted vehicle models, and can read and facetize vehicles which are in the BRL-CAD format. FRED creates a time-lapse thermal image to display the effects of air temperature, solar loading, cloud cover, and engine exercise on vehicle signatures. Using the TTIM format, the vehicle can be incorporated into thermal scenes and viewed at the bandpass of interest with the sensor of interest.

For more information, contact: E. Timothy Buxton, OptiMetrics, Inc., Ann Arbor, Michigan, (313) 973-1177.

### 6-D Comes of Age

The Bird, a 6-D input device for graphics developers who are looking for an affordable way to expand their 6-D capability is now available from Ascension Technology Corp. The Bird is less sensitive to measurement distortions from the presence of metal than conventional electromag-

netic peripherals.

The Bird uses its onboard 16-bit CPU to accurately compute the spatial position and orientation of its receiver. The package consists of the tiny receiver, which can be hand held or mounted in flexibility, and a plastic enclosure containing the transmitter and processing electronics. The transmitter can optionally be remoted, permitting a very small footprint or enabling use in tight-space environments.

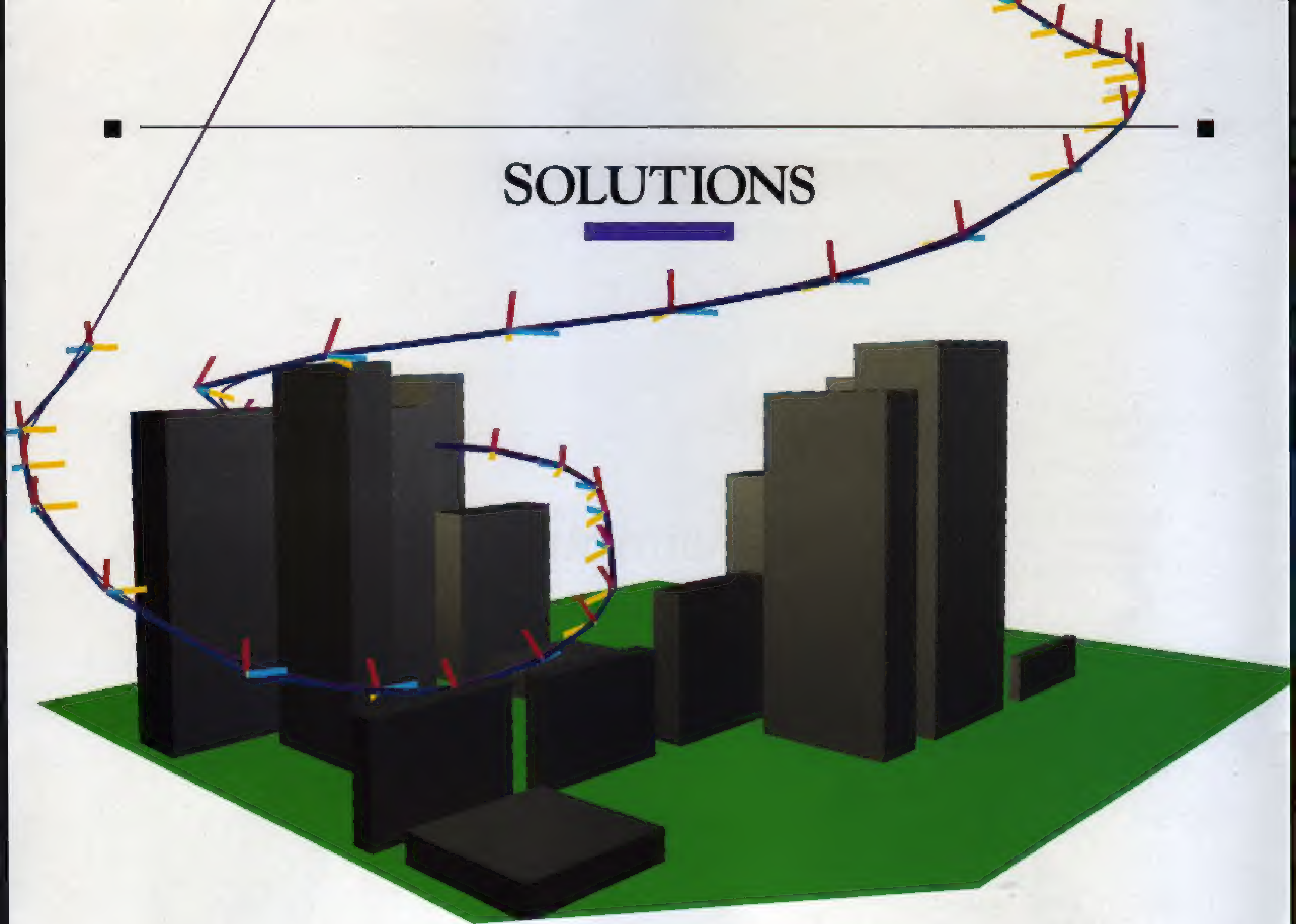
For more information, contact: Jack Scully, Ascension Technology Corp., Burlington, Vermont, (802) 655-7879.

### Interactive Data Visualization from UNIRAS

UNIRAS announces UNIGRAPH+ 2000 which offers a PC-like user interface for the analysis, visualization and presentation of data. Various chart types such as 2-D and 3-D curve charts, scattergrams, staircases, bar charts, pie charts, as well as 2-D, 3-D and 4-D image displays can be created. The data analysis capability allows users to retrieve reports, ASCII and binary files, and to customize the access routines for links to commercial database management systems.

UNIGRAPH+ 2000 produces high quality hardcopies for over 200 different output devices, including PostScript. Pictures can be exported to other systems via the creation of CGM metafiles. The user interface is based on the X-WINDOW standard and will be adapted to comply with the OSF/MOTIF Interface.

For more information, contact: Clay Harris, UNIRAS, Dallas, Texas, (214) 980-1600 or FAX (214) 991-1860.



# Using Spaceball for Animation Paths

*By James Wick*

Animation pathing requires defining a smooth path through three-dimensional space along which the direction, tilt and velocity of the camera is defined at every point. Spaceball allows you to freely generate such a path in real-time by flying through a scene with your "head in your hand". Since this taught path is probably not as smooth as desired, B-splines can be used to smooth out any irregularities. If the resulting curve is not what was intended, the entire curve can be retaught, or preferably, the portions of the curve that are erroneous can be "tugged on" interactively with Spaceball.

To achieve this, Spaceball events are used to fly around any geometry by updating a world-to-eye matrix which is used in the first multmatrix after the perspective call. At each frame, the eye position and orientation in the world coordinates, that are extracted from the inverse of this matrix, eye-to-world, are stored in an array. This dataset can be repeatedly resampled at regular intervals to determine a set of control points for a B-spline that will smooth out the original path.

Automated flight is accomplished by inserting world-to-eye matrices, that result from splining through the control points, into the first multmatrix for each frame. Alternately, you can push yourself along the path (using the Spaceball Z translation to move forward/backward along the parameter space of the spline), stop at any point and adjust the eye position and orientation of the corresponding control point with Spaceball. The spline is then recalculated using the changed control point.

The eye positions, as well as the up and forward vectors are splined; the side orientation vector is calculated as the cross product of the up and forward vectors. It is important to note that the orientation must be orthonormalized after the vectors are splined because the spline works in Cartesian space.

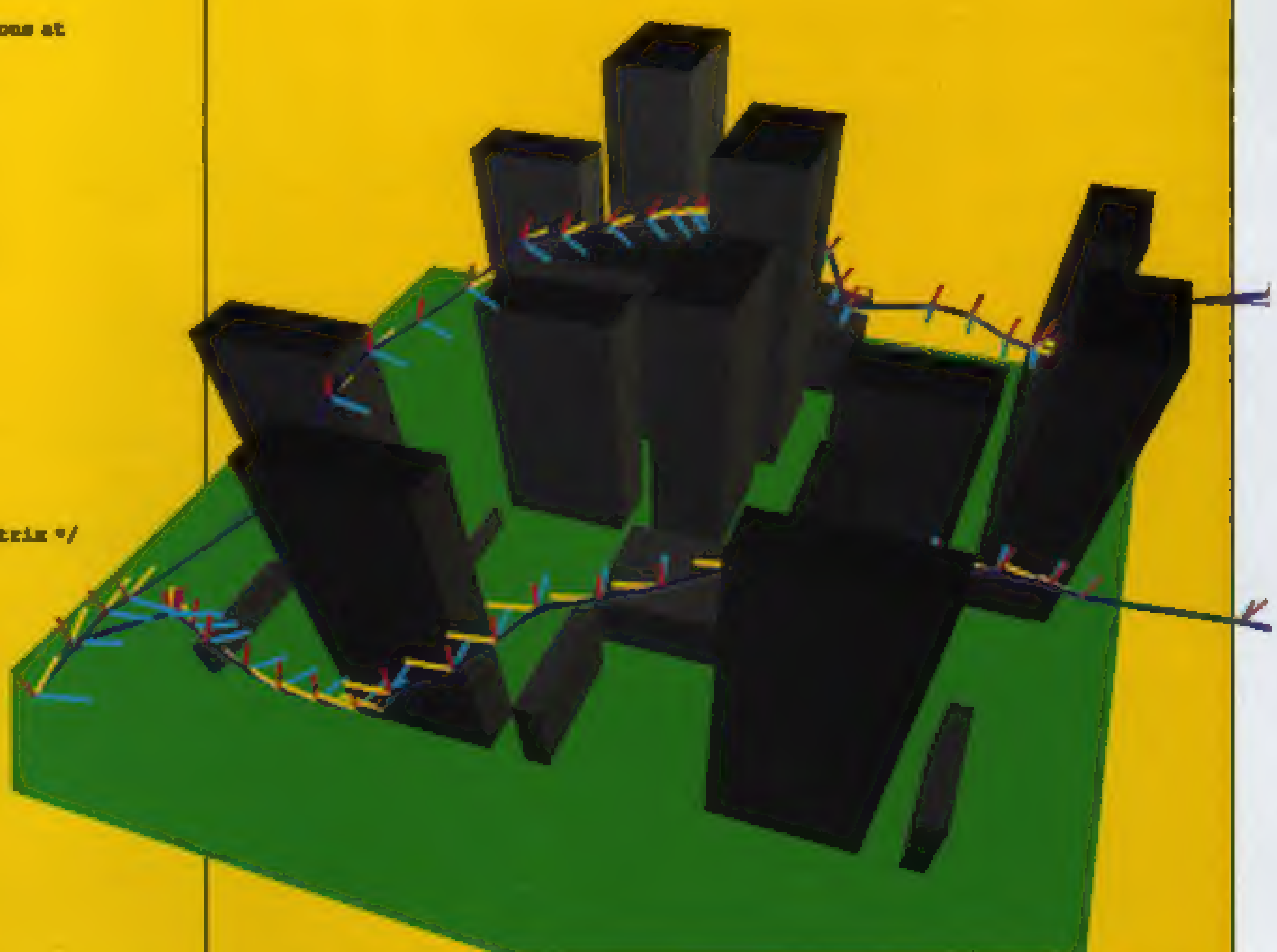
The direction of camera movement is guided along the spline; the magnitude of the camera velocity is derived from the amount of force and torque that was applied to the Spaceball during the training session and the sampling frequency.

---

*James Wick is Regional Support Manager at Spatial Systems, Inc.*

```
#include <spaceball.h>
Matrix world_to_eye, eye_to_world;

      .
      /* qdevice spaceball events */
      .

train() /* create animation path */
{

while(dev=qread(&data))
      switch(dev) {
      case SBTX:
            /* get spaceball translations & rotations */
            sbtx=data; qread(&sbty); qread(&sbtz);
            qread(&sbrx); qread(&sbry); qread(&sbrz);
            /* get time since last sb event */
            qread(&sbtime);

            /* calculate delta rotation matrix into rot using spaceball library
            routine */
            rotarbaxis(sbtime*3e-8, sbrx, sbry, -sbrz, rot);
            /* post-multiply world_to eye by rot to get new world_to_eye */
            mat_mult(world_to_eye, rot, world_to_eye);

            /* apply translation */
            world_to_eye[3][0]-=sbtx*sbtime*1e-6);
            world_to_eye[3][1]-=sbty*sbtime*1e-6);
            world_to_eye[3][2]+=sbtz*sbtime*1e-6);
            /* invert to get eye_to_world */
            mat_invert(eye_to_world, world_to_eye);

            if(recording) {
                  points[i].side_vector = ROW0_OF(eye_to_world);
                  points[i].up_vector = ROW1_OF(eye_to_world);
                  points[i].forward_vector= ROW2_OF(eye_to_world);
                  points[i].eye_pos = ROW3_OF(eye_to_world);
                  i++;
            }
            sbprompt();
            draw_frame();
            break;
      case SPACEKEY : /* done recording */
            /* fit spline to recorded points & orthonormalize rotations at
               interpolated points along the spline curve */
            spline = create_spline_and_orthonormalize(points);
            break;
      }
}
draw_frame()
{
      /* perspective could be optimized out of loop */
      perspective(fov, aspect, near, far);
      multmatrix(world_to_eye);
      /* clear & draw */
}
fly() /* code to fly along animation path */
{
      ps = spline; /* init start of spline point array */
      for(EACH_SPLINE_POINT) {
            /* could be optimized by previously storing inverted matrix */
            ROW0_OF(eye_to_world)=psspline->side_vector;
            ROW1_OF(eye_to_world)=psspline->up_vector;
            ROW2_OF(eye_to_world)=psspline->form_vector;
            ROW3_OF(eye_to_world)=psspline->eye_pos;
            mat_invert(world_to_eye, eye_to_world);
            ps++;
            draw_frame();
      }
}
adjust() /* edit animation path */
{
      .
      if(to_step_to_next_cntl_point) {
            /* ps is pointer to nearest interpolated point from spline
            control point */
            ps++;
            /* get eye_to_world from pc */
            mat_invert(world_to_eye, eye_to_world);
            draw_frame();
      .
      .
      if(moving_cntrl_pnt) {
            rotarbaxis(sbtime*3e-8, sbrx, sbry, -sbrz, rot);
            mat_mult(world_to_eye, rot, world_to_eye);
            /* should use a adaptive scale factor */
            world_to_eye[3][0]-=sbtx*sbtime*1e-6;
            world_to_eye[3][1]-=sbty*sbtime*1e-6;
            world_to_eye[3][2]+=sbtz*sbtime*1e-6;
            mat_invert(eye_to_world, world_to_eye);

            /* update position of control-point pc nearest to ps */
            pc->side_vector = ROW0_OF(eye_to_world);
            pc->up_evector = ROW1_OF(eye_to_world);
            pc->form_evector = ROW2_OF(eye_to_world);
            pc->eye_pos = ROW3_OF(eye_to_world);
            draw_frame();
      .
      if(done_moving_cntrl_pnt) {
            /* recalculate spline */
            spline = create_spline_and_orthonormalize(pc);
            .
            .
} /* adjust */
```

/rustagi — x3532, 9L-455, rustagi@sgi.com
Mgr, Applications Support Group (ASG)
Corporate Marketing

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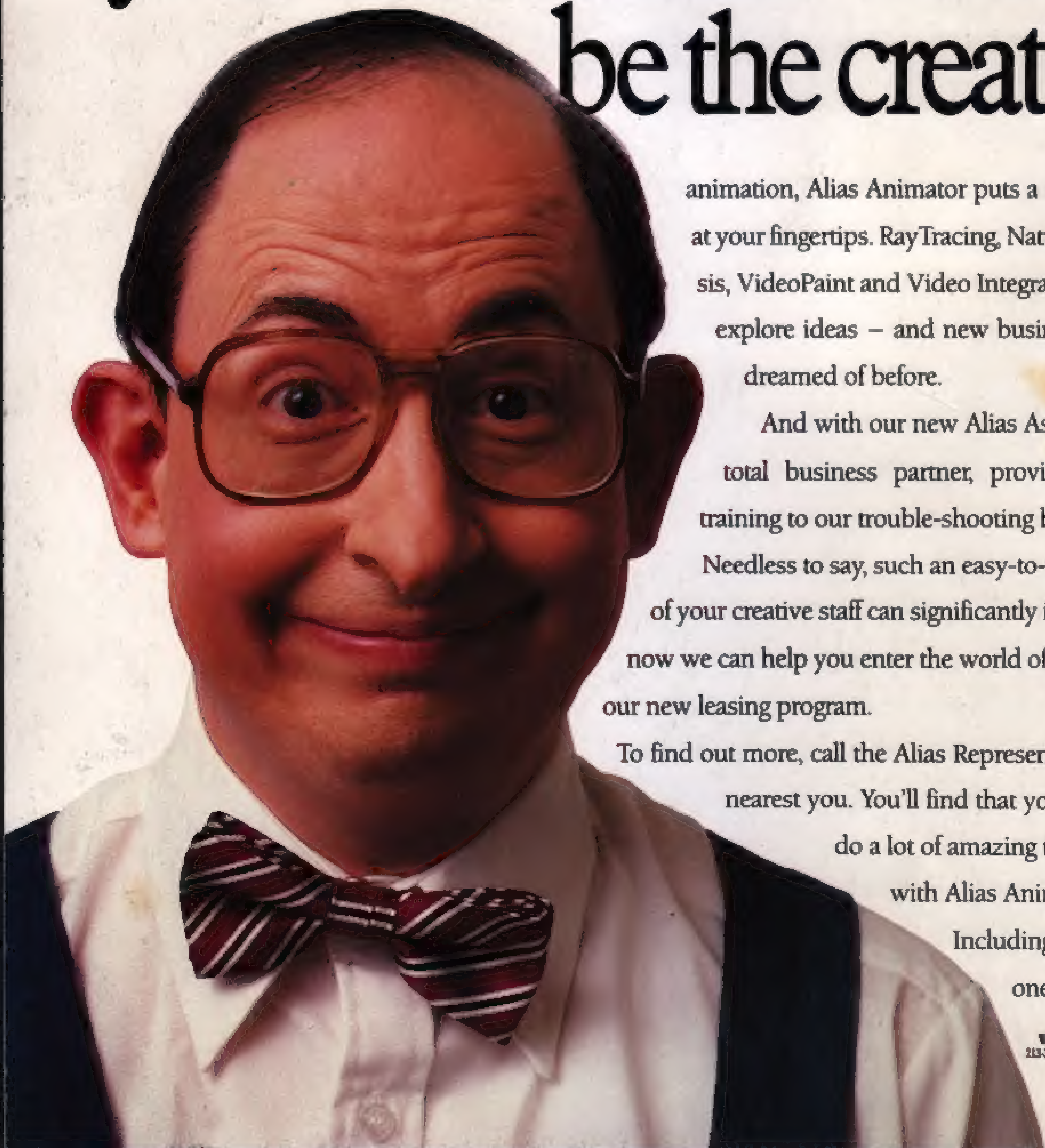

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